# JOURNAL OF DAIRY SCIENCE

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Vol. XXIV, No. 8, August, 1941

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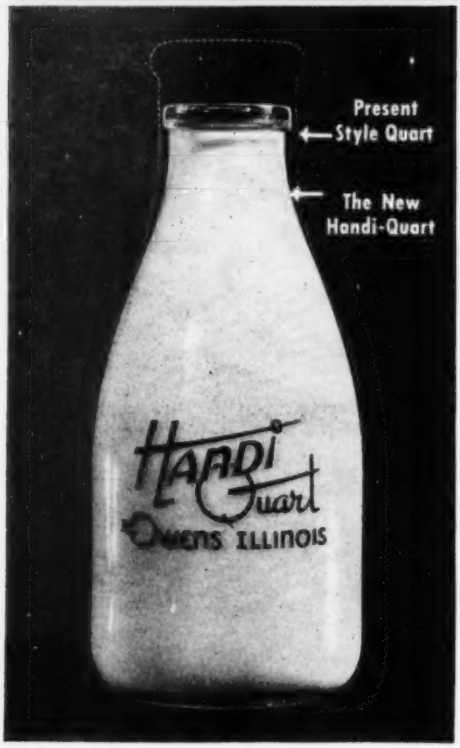


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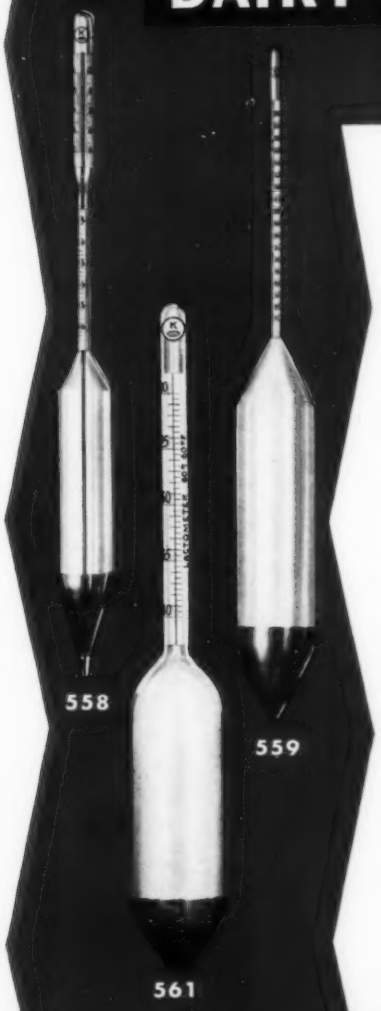


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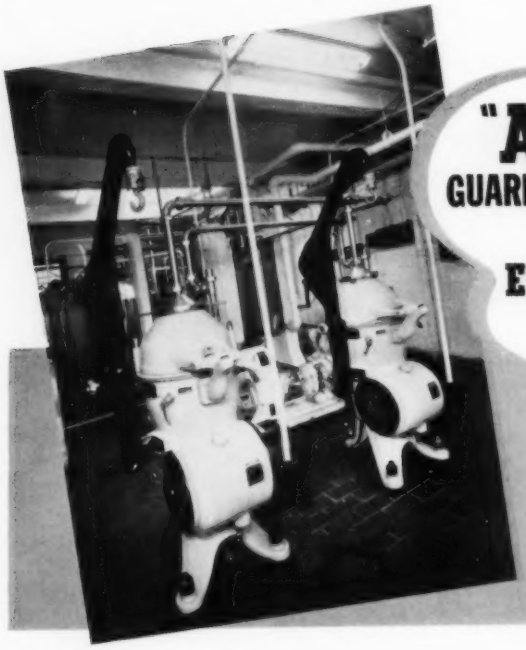

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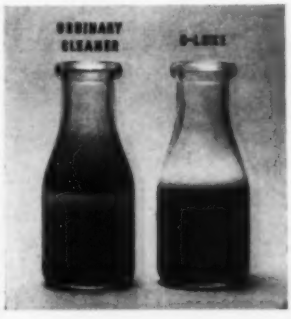


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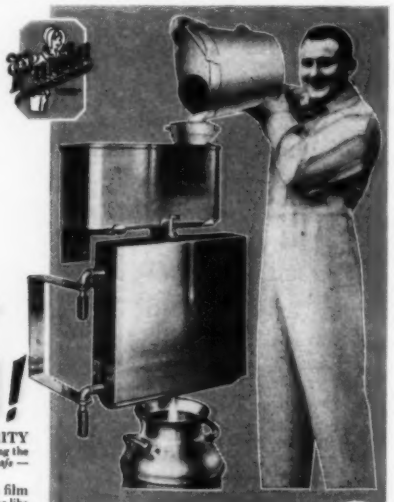

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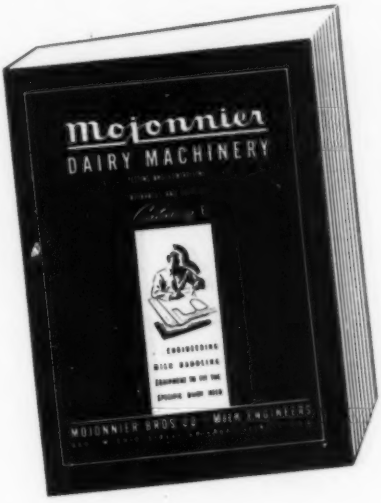


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JOURNAL OF DAIRY SCIENCE

VOLUME XXIV AUGUST, 1941 NUMBER 8

# THE RELATIONSHIP OF FAT TO QUALITY, AND METHODS OF STANDARDIZING THE FAT CONTENT, IN SWISS CHEESE

GEORGE P. SANDERS, ROBERT R. FARRAR, FRED FEUTZ, AND ROBERT E. HARDELL[1]

*Division of Dairy Research Laboratories, Bureau of Dairy Industry, U. S. Department of Agriculture*[2]

As a result of experimental research conducted in these laboratories and data obtained in factories in the Swiss cheese-producing areas in Wisconsin, Ohio, Idaho, and Pennsylvania, much information has been collected with respect to causes of variations in quality of Swiss cheese. It was shown, in results published previously (3), that the use of milk of poor bacteriological quality (methylene blue reduction time less than 3 hours) resulted in a decrease in the average grade of the cheese, and also that a complete lack of ripeness in the milk was apparently detrimental. In a recent report (4), methods were described which can be used to control the amount of moisture in the green cheese, and it was demonstrated that methods used to reduce the percentage of moisture resulted in a general improvement in quality of cheese.

This paper deals with the relationship between the percentage of fat in dry matter in the cheese and its quality, and with procedures used in predicting the percentage of fat in dry matter in the cured cheese.

## RELATIONSHIP OF PERCENTAGE OF FAT IN DRY MATTER TO QUALITY

*Factory cheese.* The relationship of percentage of fat in dry matter to quality, for 844 cured cheeses in 39 factories, is shown in figure 1. It was found that the proportion of good cheese was largest among those which contained between 45 and 46 per cent fat in dry matter. The results show also that the average quality was better in cheese containing more than 48 per cent fat in dry matter than in cheese containing less than 43 per cent.

Received for publication March 17, 1941.

[1] Resigned March 15, 1940.

[2] The work on factory cheese described herein was conducted with the cooperation of the Departments of Dairy Industry of the University of Wisconsin and the Ohio State University.



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This was true for data from 19 factories located in Wisconsin, and likewise from 18 factories located in Ohio.

The grades of some of the high-fat cheeses were reduced because the cheeses were soft, weak, or pasty in body, and because they contained "glass" or splits in the curd (glaesler defect). A large proportion of the D grade (grinder) cheeses, in several factories, were soft or weak in body. Results of recent experiments in the laboratory indicate that extreme softness or weakness of body may be a result of the use of milk that contains an abnormally low proportion of casein to other non-fatty solids, and that the presence of a high proportion of fat tends to accentuate the softness.

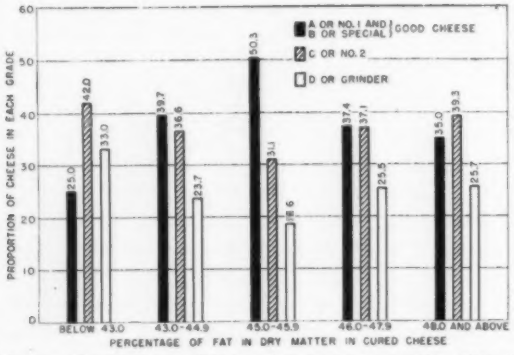


FIG. 1. Relation of percentage of fat in dry matter to quality (844 factory cheeses).

*Laboratory cheese.* Results were slightly different in the case of smaller, experimental cheese made in the laboratory plant, where the milk used is relatively high in percentage of total solids, and in curd tension, as compared with that used in the cheese-producing areas. Data for 30 pairs of experimental cheese are shown in table 1. These cheeses were the same ones for which moisture and yield data were quoted and discussed in connection with the results shown under variation No. 5 in table 3 of a former publication (4). For one cheese of each pair, the percentage of fat in the milk was reduced below that in the milk for the other by adding a relatively larger quantity of skim milk. Most of these cheeses—particularly those of low fat content—were too firm in body. This property seems to be characteristic of cheese made from high-solids, firm-curd milk, and is overcome to some extent by the incorporation of relatively more fat. The highest quality in factory cheese, on the other hand, was usually found among those which contained less fat in dry matter than was present in the best laboratory cheese.

In the experiments for which data are shown in table 1, better quality was secured in cheese containing more than 48 per cent fat in dry matter than in cheese containing less than 45 per cent. The scores of the low-fat

TABLE 1

*Data showing relationship of percentage of fat in Swiss cheese kettle milk to composition and quality of experimental cheese (averages for 30 pairs of 60-lb. cheese, cured 2-2/3 months)*

| Milk | Cured cheese | | | | | |
|---|---|---|---|---|---|---|
| Fat | Fat in dry matter | Total score | Decrease in score | | | |
| | | | Overset | Texture too firm | Glaesler defect (cracks in curd) | Flavor defects |
| % | % | *points* | *points* | *points* | *points* | *points* |
| 2.9 | 44.12 | 69.4 | 9.4 | 4.5 | 0.3 | 4.6 |
| 3.4 | 48.60 | 75.0 | 6.2 | 1.3 | 2.6 | 3.1 |

cheeses were reduced more than those of the high-fat ones for being overset, for defects in flavor, and for excessively firm body. On the other hand, a few of the high-fat cheeses contained the glaesler or curd-splitting defect, but there was less evidence of it in the low-fat ones. The low-fat cheeses rose more rapidly, and to a greater extent, than the high-fat ones. When cured, they contained an average of 0.55 per cent more moisture than the high-fat ones. Kettle whey from the low-fat cheeses contained an average of 7.23 per cent total solids and 0.50 per cent fat; corresponding data for whey from the high-fat ones were 7.44 and 0.67, respectively.

## PREDICTION OF PERCENTAGE OF FAT IN DRY MATTER

*Procedures based on analyses of samples of kettle curd.* Because of damage done to uncured cheese by taking plug samples, it is very desirable to have a reasonably accurate analytical method for securing and testing samples of kettle curd rather than of uncured or green cheese. Having data on composition of curd, and on its relationship to composition of cured cheese, the cheesemaker can alter the percentage of fat in the milk on the basis of results of curd analyses, and possibly alter the making process, in order to regulate the proportion of fat in cheese made on successive days.

*Securing and pressing samples of kettle curd.* A photograph of equipment used in securing and preparing samples of kettle curd is shown in figure 2. Two samples of kettle contents were taken immediately before dipping from a point several inches behind the brake where the curd is well mixed by the brake and where the larger particles rise to the surface in greatest numbers. Each sample was taken with a dipper having a bronze screen bottom made of 18-mesh, 28-gauge wire. The cup was $2\frac{5}{8}$ inches in height and $2\frac{1}{2}$ inches in diameter, and the length, including handle, 14 inches. Two dippers were inserted in the revolving kettle contents to a depth corresponding to the length of the handle and were withdrawn with curd contents. Whey was allowed to drain for 2 minutes, after which the curd was loosened from the sides and bottoms by tapping the dippers and curd from both dippers was then placed in one of the metal pressure cylinders. The reason for

taking two small samples instead of one large one was that the probability of securing a representative sample was thus increased.

The cylinders used for pressing the curd samples were $1\frac{7}{8}$ inch in internal diameter and $3\frac{1}{2}$ inches in height. The bottom consisted of a flat metal plate containing about 200 holes each 0.05 inch in diameter, spaced about $\frac{1}{8}$ inch apart. The construction was such that whey drained freely without curd being squeezed out. Each cylinder had 4 legs, each $\frac{1}{4}$ inch long, and was provided with a metal plunger about $3\frac{1}{16}$ inches long, of the proper diameter to fit snugly within the cylinder without binding, and weighing 1000 grams.

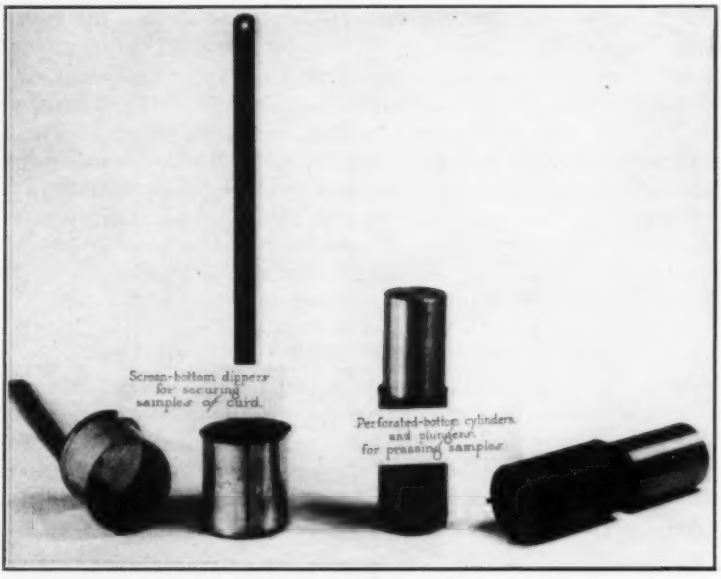


FIG. 2. Equipment for securing and preparing samples of curd from Swiss cheese kettle for analyses.

The plunger was placed upon the sample in the cylinder immediately and allowed to press for 30 minutes. The cylinder was inverted occasionally to allow whey to drain from the upper surface of the sample. The curd, when removed from the cylinder, was either analyzed at once or was wrapped tightly in tin foil, placed in a small, air-tight container, and kept in a refrigerator until analyzed.

For analyses of moisture and fat, each pressed curd sample was sliced vertically through the center, the outer portions were cut off and discarded, and thin slices were removed rapidly from the flat surface. Moisture samples were prepared by cutting the slices rapidly into small pieces with a sharp spatula in a small jar or tumbler; fat samples, by cutting the freshly-prepared slices into strips.

The equipment described above was designed and used in such a way that all curd samples were secured and prepared mechanically in a uniform manner, each one yielding a solid, compact mass which was comparatively similar to the cheese itself in consistency and in composition.

A valuable and exhaustive study of the control of composition in Swiss cheese has been made by Price (2) and his associates. They analyzed a large number of samples of kettle curd and of the corresponding cured cheese and found that the accuracy of prediction of fat in dry matter of cured cheese, based on values obtained in curd analyses, was limited to a range of 1 per cent in 66 per cent of the instances and 2 per cent in 95 per cent of the instances. In their method, referred to herein as the older method, samples of curd were taken from the kettle with a dipper, squeezed by hand to remove as much as possible of the whey, and then analyzed while in a crumbly condition.

*Relative accuracy of predictions based on curd analyses.* The accuracy of results obtained by the new, pressed-curd method was compared with the accuracy of results obtained by the older, manually-prepared curd method. Percentages of fat in dry matter found by analyzing samples of the cured cheese were taken as the actual or correct values; the amount by which the fat-in-dry-matter value of each sample of curd differed from that of the corresponding sample of cured cheese was calculated. The variations were grouped, according to size, and yielded the data shown in table 2. The results indicate that the use of the new method yielded a greater degree of precision than the use of the older one. For the new method, the average deviation of fat-in-dry-matter values of curd compared with factory-cured cheese was 0.82 per cent, and the standard deviation 1.02 per cent. For the older method, corresponding values were: Average deviation, 1.30 per cent; standard deviation, 1.69 per cent.

TABLE 2

*Data showing relative accuracy of results of two different curd-analysis methods of estimating the percentage of fat in dry matter in Swiss cheese*

| Method of sampling | Samples | | Percentage of predicted values falling within specified limits of variation from actual values found in cured cheese | | | | |
|---|---|---|---|---|---|---|---|
| | Number | Source | 0 ± 0.5 | 0 ± 1.0 | 0 ± 1.5 | 0 ± 2.0 | 0 ± 2.5 |
| | | | % | % | % | % | % |
| 1 | 49 | Laboratory | 49.0 | 87.8 | 100.0 | ..... | ..... |
| | 458 | Factory | 41.1 | 69.4 | 87.5 | 95.8 | 98.2 |
| 2 | 136 | Factory | 32.4 | 52.2 | 67.6 | 80.1 | 89.0 |

Method 1 (new method)—Analyses of mechanically-pressed samples of kettle curd.
Method 2 (old method)—Analyses of manually-prepared samples of kettle curd.

Data shown in table 2 indicate also that analytical results obtained in the laboratory were more uniform than those obtained at the numerous factories,

where conditions varied more than in the laboratory and where the most desirable types of analytical equipment, such as an analytical balance and a vacuum oven, were not in all cases available. It seems probable that results of analyses and observations made under factory conditions by careful cheesemakers might not always be as uniform as those reported herein.

*Changes in composition during pressing and curing.* In analyses of 14 samples of unpressed curd taken from the kettle with a strainer and analyzed without having been pressed, and of the corresponding green cheese, it was found that the average percentage of fat in dry matter increased from 42.5 per cent in the curd at dipping to 46.0 per cent in the cheese. Analyses of samples of the drainage whey showed that the percentage of fat in the whey draining from the cheese gradually decreased from an average of 0.60 per cent at the beginning of pressing to about 0.20 per cent at the time when drainage ended, while the percentage of solids-not-fat in the drainage whey actually increased progressively during pressing. Analyses of the cylinder-pressed curd samples, and of whey draining therefrom, showed very similar results. Koestler (1) found that the percentage of fat in the whey draining from cheese decreased progressively from 0.59 per cent to as little as 0.10 per cent, while the percentage of total dry matter in drainage whey actually increased during pressing. The cause of the increase in percentage of fat in dry matter in cheese during pressing evidently lies in the fact that the loss of solids-not-fat from cheese during drainage is relatively great in comparison with the loss of fat; and therefore the ultimate composition is influenced by the extent of drainage.

TABLE 3

*Data showing comparative average composition of curd and factory cured Swiss cheese; curd analyses made by two different methods*

| Method | Samples | | Fat | Moisture | Fat in dry matter |
|---|---|---|---|---|---|
| | Number | Source | | | |
| | | | % | % | % |
| 1. New, samples prepared by mechanical pressing | 458 | Curd | 26.07 | 42.49 | 45.33 |
| | | Cured cheese | 27.63 | 38.84 | 45.18 |
| 2. Old, samples prepared manually | 136 | Curd | 25.47 | 44.04 | 45.51 |
| | | Cured cheese | 27.55 | 39.30 | 45.39 |

The relationship of the composition of the curd, as determined by the new as well as by the old method, with that of the cured cheese is shown in the data in table 3. The percentage of moisture was somewhat higher in the samples of curd than in the cured cheese. The average percentage of moisture found in the curd samples was lower for the new method than for the older one. The average fat-in-dry-matter values for all samples of curd were in general slightly higher than those for all samples of cured cheese.

Results of the present work confirm an observation made by Price (2), who found that when the fat-in-dry-matter value of the curd was unusually low, the fat-in-dry-matter value of the corresponding cheese tended to be slightly higher, but when the fat-in-dry-matter value of the curd was unusually high the fat-in-dry-matter value of the corresponding cheese tended to be slightly lower. We found that among those curd samples whose values were below 43 per cent the average value for the corresponding cured cheese was 0.43 per cent higher, and among the curd samples whose values were above 48 per cent the average value for the corresponding cured cheese was 0.84 per cent lower. The point at which the two trends converged was approximately 44 per cent.

In order to formulate a comparative basis for estimating composition of cured cheese by means of data on composition of kettle curd or of green cheese, analyses were made of samples taken at each of these three stages from 145 laboratory cheeses and 18 factory cheeses. Resulting data are shown in table 4. It was found that the percentage of moisture was in all cases slightly greater in the cylinder-pressed curd samples than in the green cheese; also that the percentage of fat in dry matter was usually slightly less in the curd samples than in the green cheese, but greater than in the cured cheese.

TABLE 4

*Data showing average composition of Swiss cheese kettle curd and corresponding cheese, and changes in composition during curing*

A. 145 laboratory cheeses each weighing about 60 pounds

| | Fat | Moisture | Fat in dry matter | Salt |
|---|---|---|---|---|
| | % | % | % | % |
| Kettle curd, pressed | 27.02 | 41.53 | 46.21 | ..... |
| Cheese, 1 day old | 28.64 | 38.44 | 46.52 | 0.03 |
| Cheese, cured 3 months | 29.29 | 36.45 | 46.09 | 0.76 |
| Changes during curing | + 0.65 | − 1.99 | − 0.43 | +0.73 |

B. 18 factory cheeses each weighing about 180 pounds

| | Fat | Moisture | Fat in dry matter | Salt |
|---|---|---|---|---|
| | % | % | % | % |
| Kettle curd, pressed | 25.60 | 42.94 | 44.87 | ..... |
| Cheese, 1 day old | 27.37 | 39.13 | 44.96 | 0.03 |
| Cheese, cured 2½ months | 27.55 | 38.25 | 44.62 | 0.63 |
| Changes in curing | + 0.18 | − 0.88 | − 0.34 | +0.60 |

The absolute percentage of fat in the cheese increased consistently during curing. This increase is undoubtedly caused by the fact that shrinkage in curing involves principally a loss of moisture without a proportional loss of fat or of total solids. There was a consistent decrease in percentage of

fat in dry matter during curing—a decrease that was practically accounted for by the increase in dry matter resulting from the absorption of salt. The fact that the average percentage of fat in dry matter decreased by about 0.3 to 0.45 per cent during curing indicates that in order to have some assurance of securing a given average percentage of fat in dry matter in cured cheese it is necessary to have a slightly larger percentage in the kettle curd and in the green cheese.

*Calculations based on percentage of fat in kettle milk.* Since the fat test of the kettle milk is the only basis of prediction in many factories, it is desirable to determine how accurately the percentage of fat in dry matter in the cheese can be predicted from a knowledge of the percentage of fat in the milk. Therefore, calculations were made by two different methods to show the extent to which the fat-in-dry-matter value of each cheese varied or deviated from the average value, for cheese made from milk of a given fat percentage.

Method 3, based on averages for all cheese sampled: Data for 729 factory cheeses, on which milk fat tests were available, were divided into groups according to the percentage of fat in the standardized kettle milk, and the average percentage of fat in dry matter in cheese in each group was determined. Resulting data are shown in line A, figure 3. The extent to which the fat-in-dry-matter value of each cheese in a group differed from the average value for that group was then calculated. Data showing the distribution of these differences are given in Method 3, table 5.

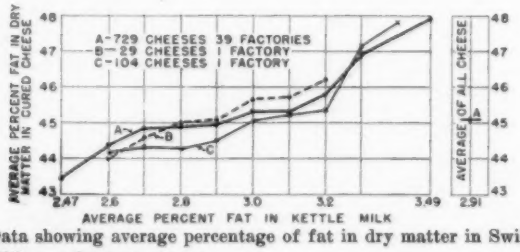


FIG. 3. Data showing average percentage of fat in dry matter in Swiss cheese made from milks of different fat percentages.

Method 4, based on averages for cheese sampled in each of 39 factories, calculated for each factory separately: Data for each factory were first divided into groups according to the percentage of fat in the standardized kettle milk used in each cheese sampled in that factory, and the average percentage of fat in dry matter in cheese in each group was determined for that factory. Resulting data for each of two representative factories are shown in lines B and C, respectively, in figure 3. The extent to which the fat-in-dry-matter value of each cheese sampled in each factory differed from the average value in that factory, for milk of a given fat percentage,

was then calculated. The differences, after being determined for each factory, were then combined and calculated to indicate their distribution, shown in Method 4, table 5.

TABLE 5

*Data showing relative accuracy of calculations based on percentage of fat in kettle milk in estimating the percentage of fat in dry matter in Swiss cheese (729 factory cheeses)*

| Method of calculation | Percentage of predicted values falling within specified limits of variation from average values found in cured cheese | | | | |
|---|---|---|---|---|---|
| | 0 ± 0.5 | 0 ± 1.0 | 0 ± 1.5 | 0 ± 2.0 | 0 ± 2.5 |
| | % | % | % | % | % |
| 3 | 26.2 | 47.3 | 62.5 | 75.8 | 83.2 |
| 4 | 34.6 | 60.5 | 77.8 | 88.5 | 94.6 |

Method 3—Based on averages for all cheese sampled; average deviation, 1.40 per cent; standard deviation, 1.76 per cent.

Method 4—Based on averages for cheese sampled in each of 39 factories, calculated for each factory separately; average deviation, 0.97 per cent; standard deviation, 1.26 per cent.

The results shown in table 5 indicate that standardization based only on the percentage of fat in the cheese milk yielded less precise results for all of the samples as a whole (Method 3) than were obtained in samples in each individual factory considered separately (Method 4). It is to be expected that the number of variables which tend to influence the composition of cheese (such as variations in solids-not-fat content of milk and in fat losses in the making process) is smaller in any one factory than in several factories located in different areas.

The results shown in table 5 indicate also that standardization based only on the percentage of fat in the milk yielded less precise results than were secured by the new, pressed-curd-analysis method (Method 1) for which data are shown in table 2.

The fact that a rather consistent relationship exists between the average percentage of fat in dry matter in the curd and that in the cured cheese (tables 3 and 4) indicates that the percentage of fat in the milk can be used to predict the percentage of fat in dry matter in the curd, and hence is a useful tool in the control of composition.

Our results show, however, that the average percentage of fat in kettle milk required to produce a given average percentage of fat in dry matter in cheese varied seasonally. Tabulations of data on 729 cheeses show that the average milk fat tests which yielded an average of 45 per cent fat in dry matter in the cheese, tabulated by months, were as follows: March, 2.81; April, 2.74; May, 2.75; June, 2.85; July, 2.81; August, 2.82; September, 3.00; October, 3.06; November, 3.08; and December, 3.00. (Data for January and February were not available.) Apparently the percentage of fat in the

standardized milk needs to be increased during the fall and winter months to maintain uniform composition in the cheese.

The results presented above indicate the approximate limits within which it should be possible to regulate, by means of analytical control, the fat in dry matter in Swiss cheese. However, if abnormal conditions (such as the occurrence of mastitis milk) are present or if the analytical facilities available are not adequate for effective control, the results of standardization may not be as uniform as those shown herein.

For efficient standardization it is essential that, in each factory, the milk in each kettle be tested and standardized; it is necessary also that tests be made frequently of the composition of kettle curd and of cured cheese, and that a set of data be prepared in the manner shown in figure 3, to be used in adjusting the percentage of fat in the milk.

Studies of the casein-fat ratio of milk are omitted from this report for the reason that tabulations of such data have not shown, for any one factory, that it is a more accurate basis than the fat test alone for predicting composition of cheese.

## SUMMARY

Tabulations of analytical and commercial grading data on 844 factory Swiss cheeses show that the highest average quality was found in cheese containing from 45 to 46 per cent fat in dry matter.

Tabulations of data on 30 pairs of laboratory cheese indicate that when the body of the cheese is relatively firm the presence of a slightly higher proportion of fat tends to improve the quality.

A new method is presented for securing and preparing, in a uniform manner, pressed samples of curd from the Swiss cheese kettle, analyses of which provide a means of estimating the percentage of fat in dry matter in the cheese. By this method, fat in dry matter in the cured cheese was estimated within one per cent in slightly more than two-thirds of the cases.

For efficient standardization it is suggested that, in each factory, the milk in each kettle be tested and standardized; that, for control purposes, pressed samples of kettle curd be secured frequently and analyzed for percentage of fat in dry matter; and that similar analyses be made frequently on samples of cured cheese.

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# AN ANALYSIS OF CONTESTANT JUDGMENTS IN THE SCORING OF DAIRY PRODUCTS WITH A STUDY OF SOME FACTORS WHICH MAY AFFECT THEM

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Questions frequently arise in the judging of dairy products relative to the effect of some factors on the efficiency of judging, particularly when a specific number of samples are judged by several groups over an extended period. Inasmuch as 2520 contestant-sample and 8190 contestant-item judgments were involved in the 1940 Students' National Contest in the Judging of Dairy Products, these data seemed to furnish an opportunity for studying what effect such factors as fatigue, order of judging, and quality of product had upon the reliability of judgments.

Sixty-three men comprising 21 teams from state colleges and universities[1] judged 10 samples each of butter, cheese, milk and ice cream. The sample judgments totaled 630 for each product, giving a sum of 2520 for the contest. In arriving at the sample judgment each contestant passed judgment on 40 items for butter (Package allowed perfect score); 30 items for cheese (Finish allowed perfect score); 30 items for milk; and 30 items for ice cream, giving a total item judgment of 2520 for butter, and 1890 each for cheese, milk and ice cream.

In dairy products judging the contestant's grade is a negative grade, being in part the difference between the official score and the contestant's score, and in part, the grade, not exceeding one point per score card item, based upon the contestant's ability to describe the quality as indicated and described by the official judge. Obviously, the contestant with the lower grade has the higher rank in judging ability, inasmuch as his judgment is closer to the official judgment.

*Grouping of Contestants.* The 63 contestants were divided into four groups so that no two team members were in any one group. Although a definite sequence of numbers was followed in grouping the contestants, the relegation of contestants to groups actually represented random sampling, inasmuch as team members and teams lined up of their own volition for contestant number assignment. In this discussion, the groups will be designated as A, B, C, and D. Groups A, B, and C each had 16 members, whereas group D had 15 members. Numbers 1, 5, 9, etc. were in group A; 2, 6, 10, etc. in Group B; 3, 7, 11, etc. in Group C; and 4, 8, 12, etc. were in Group D.

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[1] Connecticut, Cornell, Illinois, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nebraska, New Hampshire, New Jersey, Ohio, Pennsylvania, Purdue, Tennessee, Texas Technological, Vermont, Virginia Polytechnic, and Wisconsin.

*Order of Scoring.* The order of scoring each product was carried out according to the schedule in table 1.

TABLE 1

*The order of scoring and period in which scoring was done by each group*

| Group | Product assigned to group during | | | |
|---|---|---|---|---|
| | 1st period | 2nd period | 3rd period | 4th period |
| A | Cheese | Butter | Ice cream | Milk |
| B | Butter | Ice cream | Milk | Cheese |
| C | Ice cream | Milk | Cheese | Butter |
| D | Milk | Cheese | Butter | Ice cream |

Thus, three groups, A, B, and D scored ice cream following butter; three groups, A, B, and C, scored milk after ice cream; three groups, B, C, and D scored cheese after milk; and three groups, A, C, and D scored butter after cheese. The order of products scored by each group was butter, ice cream, milk, cheese, and so on regardless of the product scored first.

*Comparative Abilities of the Groups.* On the basis of total grades for all products, some differences were noted in the scoring abilities of the various groups, or some factors were operating that influenced the judging. The grades are shown in table 2.

TABLE 2

*The scoring abilities of the various groups as shown by the total grades*

| Group | Total grade per group in the scoring of | | | | |
|---|---|---|---|---|---|
| | Butter | Ice cream | Milk | Cheese | All products |
| A | 376.75[2]* | 763.45[3] | 529.95[4] | 580.40[1] | 2250.55 |
| B | 363.75[1] | 790.50[2] | 504.25[3] | 553.50[4] | 2211.50 |
| C | 373.50[4] | 704.00[1] | 533.20[2] | 464.50[3] | 2075.20 |
| D† | 392.80[3] | 769.28[4] | 533.71[1] | 548.00[2] | 2243.79 |

* Numbers 1, 2, 3, 4, indicate the period during which the scoring was done.

† Grades in Group D, composed of 15 contestants, were weighted to compare with those of Groups A, B, and C, composed of 16 members each.

On the basis of the above scores each group would have ranked in the scoring of the several products as shown in table 3.

TABLE 3

*The standings of the various groups in the judging of butter, ice cream, milk, and cheese*

| Group | Standing in the judging of | | | | Total | Rank all products |
|---|---|---|---|---|---|---|
| | Butter | Ice cream | Milk | Cheese | | |
| A | 3rd | 2nd | 2nd | 4th | 11 | 3rd |
| B | 1st | 4th | 1st | 3rd | 9 | 2nd |
| C | 2nd | 1st | 3rd | 1st | 7 | 1st |
| D | 4th | 3rd | 4th | 2nd | 13 | 4th |

From these scores and rankings it would appear that Groups B and C were slightly superior to the other two groups in judging ability.

*Distribution of First 10 Ranking Contestants per Group.* The sum of the distributions of the first ten winning individuals in each product according to group presented in table 4 shows that 6 and 15 respectively were in Groups D and C, or 21 out of the possible 40. Thus it would appear that the groups were about equally divided as to abilities except possibly Group C in which were 6 of the 10 ranking individuals in scoring ice cream. Possibly this higher number in one group in the scoring of ice cream may have been due to the period in which the scoring was done.

TABLE 4

*Distribution of the ranking 10 individuals in the scoring of each product as to group*

| Group | Number of first ten men in the scoring of products of each group | | | | Total |
|---|---|---|---|---|---|
| | Butter | Ice cream | Milk | Cheese | |
| A | 3 | 1 | 4 | 3 | 11 |
| B | 3 | 2 | 2 | 1 | 8 |
| C | 2 | 6 | 3 | 4 | 15 |
| D | 2 | 1 | 1 | 2 | 6 |

The distribution of the same individuals as to the period in which the judging was done is shown in table 5.

TABLE 5

*Distribution of the ranking 10 individuals in the scoring of each product according to period in which they judged*

| Period | Number of first 10 men in the scoring of products as to period in which judging was done | | | | Total |
|---|---|---|---|---|---|
| | Butter | Ice cream | Milk | Cheese | |
| 1st | 3 | 6 | 1 | 3 | 13 |
| 2nd | 3 | 2 | 3 | 2 | 10 |
| 3rd | 2 | 1 | 2 | 4 | 9 |
| 4th | 2 | 1 | 4 | 1 | 8 |

From the above totals, based only on the ranking 10 individuals, it would appear that the best judging was done during the first period, after which the judging was less effective. However, if the number of ranking individuals in the scoring of ice cream per period is disregarded, then the numbers of ranking individuals per period are 7, 8, 8, and 7, respectively. Apparently, from the number of the first 10 ranking individuals in the scoring of ice cream, the first period was conducive to the best judging. In summation, from the data at hand it appears that the groups were fairly well balanced as to judging ability.

*The Effect of the Preceding Product on the Efficiency of Scoring.* Con-

testants frequently give expression to the thought they would prefer to score one particular product before scoring another, probably on the assumption that it is more difficult to score some one product after having scored another, for instance, scoring milk after previously having scored cheese. The grades, therefore, were compiled in table 6 according to period to note what effect the previous product had on the judging. A study of the data shows that Groups A, D, and C each had higher grades in scoring butter than Group B. Group B started the contest by scoring butter first, whereas, each of the other three groups scored butter in turn after previously having scored cheese. The grades of groups A and C are only slightly higher and are likely not of any significance, but may indicate a trend. It must be borne in mind, however, that during the period of the contest, lasting approximately 5 hours, the butter was exposed to room temperature, so that the condition of the butter, particularly as to body, may not have been the same for each group. This factor may have offset any advantage or disadvantages of the previous product. However, the comparatively high grade of group D scoring butter in the third period would seem unexplainable. It is not unlikely that the lower grade of the group scoring butter first may have been due in part to psychological factors.

In the scoring of ice cream three groups, A, B, and D scored ice cream following butter. Here again the group scoring the product first had the lowest grade, with a rather wide margin below Groups A and B. Inasmuch as the ice cream was held in an electric refrigerator during the contest, the condition of the product, except possibly the sample exposed to show melting quality, would not have changed as did butter.

On the other hand, three groups, A, B, and C, scored milk after having scored ice cream and had equal to or slightly lower grades than Group D, which scored milk first. Since fresh samples of tempered milk were set out for each group, these differences cannot be explained on changes in the sample during the period of the contest. If not the sequence of the scoring, some other factors must have had an influence.

Finally, three groups, B, C, and D, scored cheese after having scored milk previously. From the standpoint of having the organs of the mouth in optimum condition for tasting, and by reason of contrast in intensity of flavor between products, such an arrangement would seem to be ideal for scoring cheese. And apparently it proved to be, for the three groups, instead of having higher grades than the group scoring the product first actually had materially lower grades. The cheese samples, like the butter, were exposed to room temperature during the entire contest which may have been a factor resulting in the lower grades.

*The Effect of the Period of Judging on the Efficiency of the Contestant.* The total grades per period presented in table 6 indicated that the scoring per period as the contest progressed was fairly constant. However, some

TABLE 6

*The total grade per product according to the period of judging*

| Product | Total grades according to the period of judging | | | | |
|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Total† |
| Butter | 363.25 B* | 376.75 A | 368.25 D (392.80) | 373.50 C | 1481.75 |
| Ice cream | 704.00 C | 790.50 B | 763.45 A | 721.20 D (769.28) | 2979.15 |
| Milk | 500.35 D‡ (533.71) | 533.20 C | 504.25 B | 529.95 A | 2067.75 |
| Cheese | 580.40 A | 513.75 D (548.00) | 464.50 C | 553.50 B | 2112.15 |
| All products | 2148.00 | 2214.20 | 2100.45 | 2178.15 | 8640.80 |

* Group.
† Actual total, not weighted.
‡ Numbers in parentheses weighted.

differences were noted. From the sum of grades per period, it is evident that the best judging was done in the third period followed closely by that in the first period, the poorest judging being done in the second and fourth periods, respectively. The poorest judgment in the second period, might be due to psychological factors such as a general "let down" of nervous energy or to lack of concentration resulting from retention of thought of poor judgment in the first period. The poorer judgment in the last period possibly might be explained by fatigue, or by less keenness in checking details, re-scoring and general desire to finish. Hardly may the poorer judgments of the second and fourth periods be explained on the change in the products for that factor would have held as well in the third period when the best judging was done.

*A Comparison of Average Grades on a Single Score Card Item According to Product and According to the Period of Judging.* The average contestant grade per score card item according to group and period of judging is shown in table 7. With the exception of sediment in milk only those items common to several products were included. The average contestant grade will be seen to have varied according to item, product, and period in which the judging was done, thus showing very few trends throughout the contest. However, several data are worthy of special consideration. As a general observation, the grades on flavor criticisms are of about the same value regardless of product, group, or time of judging, with slightly lower values for milk, thus showing that the contestants know the flavor criticism of each product about equally well and probably those of milk best of all. However, the range in grades on flavor score between products would indicate that contestants were at more of a loss in evaluating than in designating the flavor, particularly in scoring flavor of ice cream and milk which apparently caused

more trouble than butter and cheese. It appears that the contestants as a whole had too high an average grade on flavor score of milk considering the low grades on flavor criticism. In other words, it would seem necessary to standardize the score of milk per specific flavor criticism within limits so that the contestant would not be at so great a loss in placing a value upon the flavor encountered.

TABLE 7

*The average contestant grade per score card item by groups according to the period of judging*

| Product | Items | Average contestant grade of a group per sample when judging was done in the following period | | | |
|---|---|---|---|---|---|
| | | First | Second | Third | Fourth |
| Butter | Flavor score | 1.14 B | 1.18 A | 1.23 D | 1.03 C |
| Ice Cream | " " | 1.99 C | 2.46 B | 2.33 A | 2.33 D |
| Milk | " " | 2.04 D | 2.12 C | 1.99 B | 1.95 A |
| Cheese | " " | 1.43 A | 1.20 D | 0.93 C | 1.18 B |
| Butter | Flavor criticism | 0.58 B | 0.65 A | 0.61 D | 0.61 C |
| Ice cream | " " | 0.64 C | 0.64 B | 0.66 A | 0.72 D |
| Milk | " " | 0.51 D | 0.56 C | 0.56 B | 0.61 A |
| Cheese | " " | 0.68 A | 0.64 D | 0.61 C | 0.69 B |
| Butter | Body and texture score | 0.19 B | 0.20 A | 0.22 D | 0.30 C |
| Ice cream | " " " " | 0.92 C | 1.05 B | 0.95 A | 0.96 D |
| Cheese | " " " " | 0.90 A | 0.90 D | 0.72 C | 0.89 B |
| Butter | Body and texture criticism | 0.31 B | 0.30 A | 0.34 D | 0.36 C |
| Ice cream | " " " " | 0.58 C | 0.58 B | 0.57 A | 0.61 D |
| Cheese | " " " " | 0.52 A | 0.53 D | 0.48 C | 0.52 B |
| Milk | Sediment | 0.57 D | 0.52 C | 0.43 B | 0.48 A |
| | Total | 13.00 | 13.53 | 12.63 | 13.24 |

In scoring the body and texture of butter, ice cream, and cheese, the average contestant grade was higher for body and texture score of ice cream and cheese than for butter, since 9, 10 and 2 samples, respectively, were criticized in this respect, and since closer scoring is usually done on body and texture of butter than on ice cream and on cheese. The slight increase of average contestant grade per period in the *score* for body of butter might possibly be explained in changes occurring in the scoring condition of the butter during the contest. Likewise, there was a slight increase in the average contestant grade on body and texture *criticism* from the first to the fourth period of judging, whereas the average grades on criticisms for body and texture of ice cream and cheese remained fairly constant, from one period to another. However, it is extremely doubtful if any significance may be attributed to these increases due to changes in the product. For example, the average contestant grade for sediment in milk, a fixed factor, ranged from 0.57 in the first period to 0.43 in the second period. This difference must be explained from the standpoint of the student, not in changes in the item scored.

*Comparison of Average Contestant Grades on a Single Item per Sample per Period.* A study of the average contestant grade per sample presented in table 8 and 9 shows considerable variation in the contestant grades on flavor score between samples, particularly on flavor scores of milk and ice cream. The average contestant grade on two samples of milk, numbers 4, which was rancid and feedy, and 8, which was oxidized, were 4.22 and 3.48, respectively; that on the two garlic samples numbers 2 and 6 were 2.89 and 2.75, respectively. Likewise, in the scoring of flavor of ice cream high average grades were encountered with some samples. Apparently, the contestants for the most part were conservative and scored within a narrower range than did the official judges. If the range of official scores is considered, then the highest average grade per point of range was made in the scoring of flavor of cheese with an average of 0.40.

In the scoring of body and textures of butter, cheese and ice cream, comparatively high grades were secured with samples 3 and 9 of butter; samples 8, 9, and 10 of cheese; and samples 5, 6, and particularly 9 of ice cream thus indicating conservatism on the part of the student. It is not beyond possibility, however, that the official judges may have been somewhat severe in scoring these samples.

## SUMMARY AND CONCLUSIONS

A critical study was made of 2520 sample judgments in the scoring of butter, cheese, milk and ice cream in the 1940 Students' National Contest in the Judging of Dairy Products, involving 2520 item judgments for butter and 1890 each for cheese, milk and ice cream, a total of 8190. The 63 contestants, assigned to four groups, judged the four products during four periods of 55 minutes each.

The sequence of product judging, namely, butter, ice cream, milk, and cheese was followed throughout. The effect of the previous product on scoring was, therefore, constant except for the starting period.

The two groups scoring butter and ice cream in the first period had slightly lower grades than the groups which scored those products in the second, third, or fourth periods. On the other hand the three groups which scored cheese after having scored milk had a much lower grade than the group which scored cheese first. The best judging of milk was done in the third period.

Excitement and fatigue appeared to be factors of little consequence as indicated by the total scores of the various periods. Slightly lower grades, showing superior judging, were obtained in the third and first periods, respectively; the highest grades, showing poorest judging, being made during the second period.

Higher average grades were made on scoring flavor of milk and ice cream than on scoring flavor of butter and cheese; whereas, little difference was noted between the average grades on criticisms for the four products.

TABLE 8

*The average contestant grade on flavor score and on flavor criticism per sample per product*

| Sample No. | Official flavor | | Average contestant grade per sample on | |
|---|---|---|---|---|
| | Criticism | Score | Score | Criticism |
| **Butter** | | | | |
| 1 | Coarse | 37.0 | 1.49 | 0.80 |
| 2 | Old cream, coarse | 35.0 | 1.00 | 0.67 |
| 3 | Old cream, cheesy, neut. | 32.0 | 1.66 | 0.51 |
| 4 | ..... | 38.0 | 1.07 | 0.68 |
| 5 | Coarse, old cream | 36.5 | 0.77 | 0.64 |
| 6 | Unclean, old cream, neutralized | 35.5 | 0.92 | 0.46 |
| 7 | ..... | 38.0 | 1.13 | 0.78 |
| 8 | Coarse | 37.0 | 0.70 | 0.56 |
| 9 | Old cream | 34.0 | 0.99 | 0.59 |
| 10 | Old cream, nuetralized | 33.0 | 1.75 | 0.46 |
| | | Range 6.0 | Avg. 1.15 | 0.62 |
| | | Avg. grade per unit range 0.19 | | |
| **Cheese** | | | | |
| 1 | Flat | 39.0 | 0.90 | 0.67 |
| 2 | Unclean, acidy | 38.5 | 1.15 | 0.61 |
| 3 | Unclean, acidy | 38.5 | 1.02 | 0.63 |
| 4 | Unclean, acidy | 38.5 | 0.91 | 0.67 |
| 5 | Unclean, acidy | 38.0 | 0.93 | 0.63 |
| 6 | Flat | 39.0 | 1.40 | 0.94 |
| 7 | Acidy | 37.0 | 1.31 | 0.52 |
| 8 | Unclean | 36.0 | 1.76 | 0.58 |
| 9 | Unclean | 37.0 | 1.40 | 0.69 |
| 10 | Unclean | 37.0 | 1.28 | 0.65 |
| | | Range 3.0 | Avg. 1.21 | 0.66 |
| | | Avg. grade per unit range 0.40 | | |
| **Milk** | | | | |
| 1 | Sl. cooked | 22.0 | 0.62 | 0.44 |
| 2 | Garlic | 14.0 | 2.89 | 0.53 |
| 3 | Unclean | 19.0 | 1.90 | 0.93 |
| 4 | Rancid, feed | 16.0 | 4.22 | 0.75 |
| 5 | Feed | 21.0 | 1.22 | 0.46 |
| 6 | Garlic | 16.0 | 2.75 | 0.70 |
| 7 | ..... | 23.0 | 0.74 | 0.33 |
| 8 | Oxidized | 15.0 | 3.48 | 0.22 |
| 9 | Sl. cooked | 22.0 | 1.58 | 0.67 |
| 10 | Sl. cooked | 21.5 | 0.92 | 0.60 |
| | | Range 9.0 | Avg. 2.03 | 0.56 |
| | | Avg. grade per unit range 0.22 | | |
| **Ice Cream** | | | | |
| 1 | ..... | 45.0 | 1.50 | 0.78 |
| 2 | Lacks fine flavor | 44.0 | 1.21 | 0.56 |
| 3 | ..... | 45.0 | 2.37 | 0.93 |
| 4 | Unnatural, metallic, old ingredient | 38.0 | 3.02 | 0.55 |
| 5 | Lacks fine flavor | 42.5 | 2.03 | 0.76 |
| 6 | Old ingredient, oxidized | 39.0 | 3.05 | 0.65 |
| 7 | Unnatural, old ingredient | 38.5 | 3.04 | 0.56 |
| 8 | Lacks fine flavor, lacks sugar | 43.5 | 1.00 | 0.59 |
| 9 | Old ingredient, storage feed, oxidized | 36.0 | 3.69 | 0.47 |
| 10 | Lacks fine flavor | 44.5 | 1.92 | 0.71 |
| | | Range 9.0 | Avg. 2.28 | 0.65 |
| | | Avg. grade per unit range 0.25 | | |

TABLE 9

*The average contestant grade on body and texture score and on body and texture criticism per sample per product*

| Sample No. | Official body and texture | | Average contestant grade per sample on | |
|---|---|---|---|---|
| | | Score | Score | Criticism |
| | **Butter** | | | |
| 1 | ..... | 25.0 | 0.09 | 0.08 |
| 2 | ..... | 25.0 | 0.22 | 0.24 |
| 3 | Crumbly | 24.5 | 0.43 | 0.81 |
| 4 | ..... | 25.0 | 0.07 | 0.13 |
| 5 | ..... | 25.0 | 0.34 | 0.48 |
| 6 | ..... | 25.0 | 0.14 | 0.16 |
| 7 | ..... | 25.0 | 0.14 | 0.22 |
| 8 | ..... | 25.0 | 0.08 | 0.16 |
| 9 | Crumbly | 24.5 | 0.50 | 0.75 |
| 10 | ..... | 25.0 | 0.30 | 0.29 |
| | | Range 0.5 | Avg. 0.23 | 0.33 |
| | | Avg. grade per unit range 0.46 | | |
| | **Cheese** | | | |
| 1 | Open | 29.0 | 0.58 | 0.32 |
| 2 | Mealy, open | 28.5 | 0.42 | 0.58 |
| 3 | Mealy, open | 28.0 | 0.71 | 0.55 |
| 4 | Pasty, open | 28.0 | 0.54 | 0.48 |
| 5 | Mealy, open | 28.0 | 0.58 | 0.50 |
| 6 | Open, sw. c. holes | 28.5 | 0.64 | 0.46 |
| 7 | Mealy | 28.0 | 0.78 | 0.74 |
| 8 | Gassy, yeast slits, curdy | 26.0 | 1.50 | 0.65 |
| 9 | Gassy, yeast slits, curdy | 26.0 | 1.48 | 0.50 |
| 10 | Gassy, yeast slits, curdy | 26.0 | 1.30 | 0.40 |
| | | Range 3.0 | Avg. 0.85 | 0.52 |
| | | Avg. grade per unit range 0.28 | | |
| | **Ice Cream** | | | |
| 1 | ..... | 24.5 | ..... | ..... |
| | or curdy | 24.0 | 0.60 | 0.53 |
| 2 | ..... | 24.5 | 0.71 | 0.75 |
| 3 | Curdy | 24.0 | 0.58 | 0.55 |
| 4 | ..... | 24.5 | ..... | ..... |
| | or curdy | 24.0 | 0.71 | 0.70 |
| 5 | Icy, weak | 22.0 | 1.27 | 0.55 |
| 6 | Icy, gummy (soggy) | 22.0 | 1.15 | 0.52 |
| 7 | Icy | 22.0 | 0.98 | 0.30 |
| 8 | ..... | 24.5 | 0.73 | 0.84 |
| 9 | Buttery, gummy (soggy), icy, curdy, does not melt | 20.0 | 2.50 | 0.60 |
| 10 | Wheys off, curdy, crumbly, does not melt | 23.5 | 0.52 | 0.57 |
| | | Range 4.5 | Avg. 0.97 | 0.59 |
| | | Avg. grade per unit range 0.21 | | |

Contestants appeared to be more conservative in scoring strong off-flavors of milk and ice cream than the official judges.

The change in body and texture of the products during the progress of

the contest as affecting its scorability would seem to be of minor importance, dependent upon the product; changes in cheese being of little consequence; changes in ice cream negligible, except possibly for melting quality; whereas, changes in body of butter were such as to increase slightly the average contestant grades per period of judging.

The distribution of the 10 ranking individuals per period was quite uniform except in the judging of ice cream when 6 of the 10 ranking individuals scored ice cream in the first period.

# IN VIVO STUDIES OF HYDROGEN ION CONCENTRATIONS IN THE RUMEN OF THE DAIRY COW

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## INTRODUCTION

The rumen of herbivorous animals plays an essential and important role in the digestive process although no digestive juices are secreted in the rumen. Moisture, body heat, and rumen motility provide an excellent environment for the fermentation and maceration of the coarse, bulky, and fibrous material that constitutes the major portion of the herbivore's diet. Cellulose, the main constituent of the crude fiber of plant foods, is utilized by herbivorous animals. Dukes (2) states that bacteria are the chief agencies involved in cellulose digestion and suggests that bacteria ferment cellulose to glucose. For optimal bacterial activity, the hydrogen ion concentration needs to be within a certain range. With possible acid production from carbohydrate fermentation, the pH of rumen ingesta should be influenced by types of feed consumed, which in turn may have a regulatory action on bacterial activity.

Kick and co-workers (3) reported studies with steers on the pH of rumen ingesta. Their determinations varied with rations fed from pH 5.5 to 7.7 with the most alkaline reaction on alfalfa hay alone.

Monroe and Perkins (4) made *in vitro* determinations of the hydrogen ion concentration of rumen ingesta. The pH determinations were made with a Leeds and Northrup portable potentiometer with a saturated calomel half cell and a quinhydrone electrode. Rumen contents were sampled in six different localities and pH readings were taken on uncentrifuged liquid expressed from the ingesta. They gave an average pH value between 6.83 and 7.01 when their animals were fed roughages such as corn and A.I.V silage, and alfalfa hay. A slightly more acid reaction was obtained when the animals were pastured on bluegrass and alfalfa. They reported rumen contents of slaughtered animals to have an average pH of 7.34.

Previous work done at this laboratory showed that some body fluids undergo rapid changes in pH when exposed to air. For this reason it was thought that *in vivo* determinations would be nearer the actual hydrogen ion concentration.

## EXPERIMENTAL ANIMALS AND METHODS

The experimental animals used in this study were two Holstein cows with

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permanent rumen fistulas. Both animals were kept in stanchions. Water was available at all times from fountains. One of the animals was used as a nurse cow and the other was milked during the experimental period. The fistulas were not kept closed and a small amount of ingesta was lost when the animals were lying down.[1]

A Beckman pH meter with a glass electrode assembly constructed for such purposes was used in the work. The customary potassium chloride calomel electrode in this assembly is replaced by a silver-silver chloride electrode.

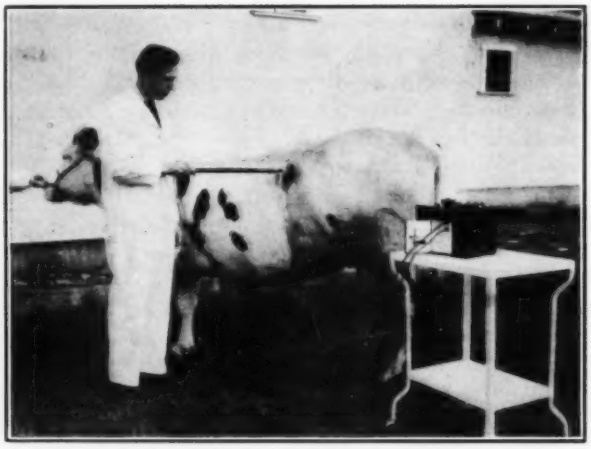

FIG. 1. Illustrates method of making pH readings and equipment used.

This electrode is located on the body of the glass electrode some four inches from the ground portion and connects through the glass to the lead wire provided with a phone tip. The electrode and extension jacket measure 23.5 inches, and are connected to the pH meter by a ten-foot lead.

The electrode was inserted into the rumen, and PH readings were made in six different localities. Readings designated as front were taken in the immediate vicinity of the cardia approximately two inches below the ingesta level. Deep front readings were made with the electrode near the reticulum and a few inches above the floor of the rumen. The middle readings were made in the dorsal sac near the surface and the deep middle readings from the ventral sac an inch or two above the floor of the rumen. Rear and deep

[1] In this study the rumen fistulas were not kept closed because it was found more convenient to take readings in various locations in the rumen. Since submitting this paper for publication, additional studies have been made which show that the pH of the rumen was slightly more acid (0.30) with a closed fistula.

rear readings were made in the dorsal and ventral posterior blind sacs of the rumen respectively.

The experimental period on alfalfa for animal No. 1 was two weeks previous to the corresponding period for animal No. 2. Alfalfa hay and beet pulp experimental periods were simultaneous for the two animals. In order to insure a homogenous ingesta, beet pulp was fed one week prior to the beginning of the experimental period. Readings were made three times a day over a period of five successive days for each animal on each ration. In addition, there were 24-hour periods at the end of the five-day experimental periods in which readings were made every two hours.

## RESULTS OBTAINED

Results of pH readings when the animals were on a sole alfalfa hay ration are given in table 1. Means for the various periods represent 30 readings and an overall mean 90 readings. The mean for the 24-hour period is for 72 readings. The readings on animal No. 1 ranged from pH 5.65 to 6.78. The mean pH readings of the 7 : 30 A.M., 12 : 30 P.M., and 5 : 30 P.M. were pH 6.44, 6.22, and 6.13, respectively. The overall mean or mean of all readings for animal No. 1 was pH 6.26. The 24-hour period had a mean pH of 6.29. The range in pH for animal No. 2, when receiving alfalfa hay alone, was 5.85 to 6.85. Means for the various hours are as follows: 7 : 30 A.M., pH 6.43; 12 : 30 P.M., pH 6.24; and 5 : 30 P.M., pH 6.20, with an overall mean of pH 6.29. Mean of the 24-hour period is pH 6.31.

TABLE 1

*Comparison of pH means when animals were fed alfalfa hay alone*

| Experimental animal | pH means of the various periods | | | | |
|---|---|---|---|---|---|
| | 7 : 30 A.M. | 12 : 30 P.M. | 5 : 30 P.M. | Overall | 24-hour period |
| No. 1 | 6.44 | 6.22 | 6.13 | 6.26 | 6.29 |
| No. 2 | 6.43 | 6.24 | 6.20 | 6.29 | 6.31 |

Table 2 gives the summary of pH readings when the animals received 20 pounds of molasses beet pulp in addition to alfalfa hay ad libitum. For animal No. 1 there was a range in readings from pH 5.29 to 6.54. The mean pH of 7 : 30 A.M. readings is 6.15; of 12 : 30 P.M., pH 5.82; and of 5 : 30 P.M., pH 5.93, with an overall mean of pH 5.97. The 24-hour period mean is pH 6.07.

The range of readings for animal No. 2 was pH 5.55 to 6.59, a mean pH of 6.14 for the 7 : 30 A.M., 6.01 for the 12 : 30 P.M., 5.95 for the 5 : 30 P.M. readings, and an overall mean of pH 6.03. On the readings over the 24-hour period there was a mean pH of 6.07.

From these data it can be seen that the results are consistent. The pH was highest at the 7 : 30 A.M. readings and lowest at 5 : 30 P.M. The feeding

TABLE 2

*Comparison of pH means when animals were fed alfalfa hay and beet pulp*

| Experimental animal | pH means of the various periods | | | | |
|---|---|---|---|---|---|
| | 7: 30 A.M. | 12: 30 P.M. | 5: 30 P.M. | Overall | 24-hour period |
| No. 1 | 6.14 | 6.01 | 5.95 | 6.03 | 6.07 |
| No. 2 | 6.15 | 5.82 | 5.93 | 5.97 | 6.07 |

of beet pulp increased the acidity of the ingesta appreciably. This is evidenced when the pH readings on the beet pulp plus alfalfa hay are compared to the readings of hay alone.

Table 3 presents the comparison of *in vitro* and *in vivo* determinations.

TABLE 3

*Comparisons of in vitro and in vivo pH determinations of rumen ingesta*

| Determination made | Locations from which samples or readings were taken | | | | | |
|---|---|---|---|---|---|---|
| | Front | Deep front | Middle | Deep middle | Rear | Deep rear |
| Experimental Animal No. 1 | | | | | | |
| *In vitro* | 6.90 | 6.55 | 6.57 | 6.43 | 6.50 | 6.57 |
| *In vivo* | 6.32 | 6.32 | 6.32 | 6.28 | 6.28 | 6.25 |
| Experimental Animal No. 2 | | | | | | |
| *In vitro* | 6.88 | 6.49 | 6.61 | 6.23 | 6.17 | 6.10 |
| *In vivo* | 6.35 | 6.40 | 6.10 | 6.02 | 5.83 | 6.16 |

The *in vitro* pH determinations were made on liquid from ingesta taken from the same parts of the rumen where the *in vivo* readings were made. Samples of ingesta were taken immediately after *in vivo* readings. The *in vitro* determinations were completed within 30 minutes after the samples were taken. The customary potassium chloride calomel electrode was used in making the *in vitro* readings. Table 3 shows that the *in vitro* values were more alkaline than the *in vivo* values in all cases except one.

TABLE 4

*Mean pH readings of rumen ingesta in various parts of the rumen*

| Front | Deep front | Middle | Deep middle | Rear | Deep rear |
|---|---|---|---|---|---|
| 6.27 | 6.20 | 6.05 | 6.13 | 6.00 | 6.13 |

Mean pH values of rumen ingesta in various parts of the rumen are given in table 4. Means are of readings on both rations and each figure represents 30 pH determinations. The front reading, which was taken near the cardia, has the highest pH value. This is logical, since the 7: 30 A.M. and 5: 30 P.M. readings were made shortly after the animals were fed. Dukes (2), Kick and associates (3), and Monroe and Perkins (4), assess saliva a pH of 8.00

and over. The contractions of the reticulum keep the ingesta in the cardia region well bathed with liquid ingesta. Rear and middle readings are more acid and were made in the moist ingesta; whereas the deep front, deep middle, and deep rear readings were taken in the more liquid ingesta composed of suspended material, ingested water, and salivary secretions, and were more alkaline.

Figure 2 presents graphically the means of the pH readings at two-hour intervals on animal No. 1. The animal was fed at 7:30 A.M. and 5:30 P.M. The curve representing the alfalfa hay pH readings shows a gradual increase in alkalinity up to 9:00 A.M. after which there is a downward trend until 11:00 A.M. The pH takes an upward trend from then until 5:00 P.M. With minor fluctuations, there is a gradual rise to 1:00 A.M., the high point of the period with pH 6.47. The broken line, which indicates the trend of the mean pH readings on beet pulp, has the highest pH of the day at 7:00 A.M., or thirty minutes before being fed. There is an increase in pH from 1:00 P.M. to 5:00 P.M., a decline to the low point of the day at 9:00 P.M., and a general rise to 3:00 A.M.

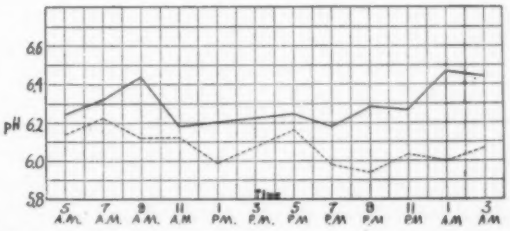


FIG. 2. Means of pH readings taken at two-hour intervals, experimental animal No. 1. Continuous line-alfalfa hay alone, broken line-alfalfa hay and beet pulp.

Figure 3 represents means for animal No. 2. The high point in the continuous line curve is at 9:00 A.M., after which there is a constant decline to 5:00 P.M., an incline to 7:00 P.M., a drop to 9:00 A.M., a slight rise at 11:00 P.M., a lowering at 1:00 A.M., and a rise at 3:00 A.M. The curve for the beet pulp was comparable to the alfalfa curve in that it reached its peak at 9:00 A.M. Another high point occurred at 3:00 P.M., followed by a general trend downward to 11:00 P.M. The curve then takes an upward swing to 3:00 A.M. A study of the graphs shows that the mean pH values on the alfalfa hay and beet pulp ration are without exception lower than the values on the alfalfa alone.

The curves do not follow any consistent pattern with respect to time of day. The fluctuations of these curves are probably influenced by large amounts of saliva entering the rumen during rumination. Schalk and Amadon (5) state that the ox secretes approximately 15 gallons of saliva per day and that 50 per cent of rumen ingesta consists of ingested water and

salivary secretions. They explain that the remasticated bolus is deposited in the anterior dorsal sac of the rumen. Saliva accompanying the bolus would have the opportunity of being mixed with rumen ingesta. Water follows the same path as the bolus and may be a factor in causing pH fluctuations.

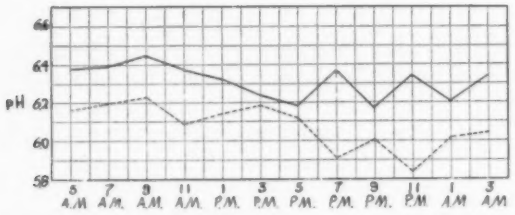


FIG. 3. Means of pH readings taken at two-hour intervals, experimental animal No. 2.

## DISCUSSION

Significance of pH in the rumen is as yet unknown. Hydrogen ion concentration may be a factor in bloat in that it may provide optimum conditions for fermentation activities of bacteria and the formation of gases. Dougherty (1) has shown that gas is absorbed from the rumen and that the rate of absorption is increased with an increase of intraruminal pressure. Carbon monoxide was found to be a gas common to the rumen and was capable of producing symptoms of distress in low concentrations when ruminal pressure was increased. Later unpublished work by the same author indicates the hydrogen ion concentrations of the rumen may have a marked influence on the production and the absorption of hydrogen sulfide into the blood stream. The later-mentioned gas was thought to be an important cause of some of the symptoms of acute bloat. Raising or lowering of pH in rumen ingesta may result from the accumulation of products of bacterial activity.

Mean pH values determined in this work are lower than those reported by other workers. These lower values may be due to the fact that pH determinations were made *in vivo*. The more alkaline values for the *in vitro* determinations are possibly due to the loss of $CO_2$ from the *in vitro* samples.

## SUMMARY

Hydrogen ion determinations were made on rumen ingesta, using as experimental subjects two cows with permanent rumen fistulas.

Readings of pH were taken three times a day over a period of five days and at two-hour intervals over a period of 24 hours for two different rations.

A mean hydrogen ion concentration of 6.27 for alfalfa hay alone and 6.00

for alfalfa hay and beet pulp was obtained over a period of five days with three-times-a-day readings.

Over the 24-hour period with two-hour-interval readings, the mean pH for the alfalfa ration is 6.30 and for the alfalfa and beet pulp ration 6.07.

Rumen ingesta fluctuate in hydrogen ion concentration throughout the day but the ingesta are generally more alkaline shortly before and after feeding.

Mean hydrogen ion concentration readings varied from pH 6.27 in the front to pH 6.00 in the rear of the rumen.

Lower pH values were obtained by *in vivo* pH determinations than by *in vitro* determinations.

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# THE SIGNIFICANCE OF LIPOLYSIS IN THE CURD TENSION AND RENNET COAGULATION OF MILK. I. THE ROLE OF FAT GLOBULE ADSORPTION "MEMBRANE." II. THE EFFECT OF THE ADDITION OF CERTAIN FAT ACIDS TO MILK

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The relatively low curd tension of fresh sweet cream buttermilk (1, 2) and the failure to clot with rennet of buttermilk obtained from certain creams having other than a natural fat globule adsorption "membrane" (3) have been attributed by Tarassuk and Palmer (3), Palmer and Tarassuk (4) to two possible factors: 1. The curd tension reducing effect of adsorption "membrane" protein as the result of its possible partial denaturation in the process of churning of cream; 2. The interference of certain fat acids with a normal clotting of milk by rennet. The fat acids are liberated by partial hydrolysis of milk fat, which, presumably takes place under certain conditions on the replacement of a natural adsorption "membrane" around the fat globules.

In the present report experimental evidence is submitted to show (a) the extent and significance of lipolysis in curd tension reduction of milk and buttermilk by fat globule "membrane" replacement and (b) the conditions under which certain free fat acids when present in milk will completely inhibit the clotting of milk by rennet.

## EXPERIMENTAL

The creams having other than a natural fat globule "membrane" were prepared as described in detail previously (3). Essentially, the procedure was as follows: Fresh, pure butter fat is emulsified in an aqueous solution of the desired emulsifying agent to give the synthetic cream. By diluting this cream with normal fresh skim milk "remade" whole milk is obtained. Centrifugal separation of the "remade" cream on churning produces "remade" buttermilk.

The curd tension, surface tension, pH, . . . values, were determined as described in a previous paper (3). The official method (1936) was employed for the determination of free fatty acids and the values obtained are expressed as acid degree of fat (ml. of 1N NaOH required to neutralize the free acids in 100 grams of fat).

### I. THE EFFECT OF LIPOLYSIS ON CURD TENSION AND RENNET COAGULATION OF "REMADE" MILKS

In the previous work (2, 3) dealing with the effect of fat globule "mem-

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brane'' material on the curd tension of ''remade'' milks, the source of milk plasma for such milk was a normal raw skim milk. The employment of raw skim milk inadvertently introduced the possibility of lipolysis as suggested by the abnormally low surface tension and pH value of the ''remade'' buttermilks. In a later report of Palmer and Tarassuk (4) it was shown that when diglycol laurate was added to milk, or used as an emulsifying agent, the hydrolysis of the ester always took place when a raw milk was employed. The hydrolysis of diglycol laurate in milk led, under certain conditions, either to reduced curd tension or to a total inhibition of clotting by rennet. In order to evaluate 1, the effect of adsorption ''membrane'' material and 2, the effect of possible lipolysis on the curd tension of ''remade'' milks, we have repeated independently the essential experiments of Tarassuk and Palmer (3) with the additional modification of using pasteurized skim milk as the source of milk plasma for ''remade'' milks.

Table 1 presents the typical results obtained. In experiment I, the only difference between (a) and (b) parts was that raw skim milk was employed in (a) and identical skim milk pasteurized by holding method was used in (b). The ''remade'' milks in this experiment were made from the same gelatin cream.

Two important things are evident from the examination of the pH and the surface tension values of ''remade'' milks in table 1: 1. Whenever a pasteurized skim milk instead of raw milk was used as the source of milk plasma for ''remade'' milks, there was no significant lipolysis in ''remade'' whole milks or in ''remade'' buttermilks, and 2. In the absence of lipolysis the curd tension reduction in ''remade'' buttermilks was relatively small. No complete inhibition of clotting of buttermilk by rennet was observed in any of these cases. On the other hand, in the experiments which were exactly the same in every respect except that a raw skim milk was used as the source of milk plasma for ''remade'' milks, our data are in complete agreement with the data obtained by Tarassuk and Palmer (3). The ''remade'' buttermilks in this instance, on aging at a low temperature, did not show the slightest visible coagulation on the addition of more rennet than was ordinarily sufficient to produce practically instantaneous clotting. The above ''remade'' buttermilks were characterized by abnormally low pH and surface tension values, suggesting the presence of free fat acids as the result of a rather extensive lipolysis. Though to a much smaller degree than in ''remade'' buttermilk, lipolysis was also evident in ''remade'' whole milks if their source of milk plasma was a raw skim milk. Further evidence of hydrolysis of fat in ''remade'' milks whose milk plasma was a raw skim milk is given in table 3.

It should be noted that in the present experiments, as in the experiments of Tarassuk and Palmer (3), the degree of dispersion of fat globules in synthetic creams was similar to that of natural cream as determined micro-

TABLE 1

*Curd tension, pH, surface tension and composition of "remade" milk from gelatin and acid whey powder creams*

| Experiment No. | Product tested | Curd tension | pH | Surface tension at 20–21° C. | Fat | Solids-not-fat | Remarks |
|---|---|---|---|---|---|---|---|
| | | *gm.* | | *dynes per cm.* | % | % | |
| I | Gelatin creams | | | | | | |
| | (a) *Source of milk plasma: raw skim milk* | | | | | | |
| | (1) Original skim | 80 | 6.56 | 53.9 | 0.02 | 9.38 | (1) On aging at 7° C. for two hours. |
| | "Remade" whole | 50 | 6.49 | 46.2 | 3.93 | 7.89 | |
| | "Remade" skim | 50 | 6.51 | 49.0 | 0.12 | 8.38 | |
| | "Remade" buttermilk | 35 | 6.12 | 38.5 | 0.30 | 8.31 | |
| | (2) Original skim | 82 | ..... | ..... | ..... | ..... | (2) On aging at 7° C. for 44 hours. |
| | "Remade" whole | 45 | ..... | ..... | ..... | ..... | |
| | "Remade" skim | 54 | ..... | ..... | ..... | ..... | |
| | "Remade" buttermilk | 0 | 6.05 | ..... | ..... | ..... | |
| | (b) *Source of milk plasma: pasteurized skim milk* | | | | | | |
| | (1) "Remade" whole | 46 | 6.63 | 50.4 | 4.20 | 8.13 | (1) On aging at 7° C. for two hours. |
| | "Remade" skim | 50 | 6.60 | 53.9 | 0.02 | 8.58 | |
| | "Remade" buttermilk | 36 | 6.60 | 49.0 | 0.80 | 8.10 | |
| | (2) "Remade" whole | 40 | ..... | ..... | ..... | ..... | (2) On aging at 7° C. for 44 hours. |
| | "Remade" skim | 50 | ..... | ..... | ..... | ..... | |
| | "Remade" buttermilk | 32 | 6.53 | ..... | ..... | ..... | |
| II | Whey powder cream *Source of milk plasma: raw skim milk* | | | | | | |
| | Original skim | 68 | 6.63 | 53.9 | 0.04 | 9.00 | On aging at 4° C. for two hours. |
| | "Remade" whole | 46 | 6.56 | 45.5 | 4.00 | 7.62 | |
| | "Remade" skim | 55 | 6.66 | 46.2 | 0.15 | 7.95 | |
| | "Remade" buttermilk | 0 | 6.19 | 37.8 | 0.85 | 7.58 | |
| III | *Source of milk plasma: pasteurized skim milk* | | | | | | |
| | Original skim | 40 | 6.56 | 53.9 | 0.03 | 8.92 | On aging at 4° C. for two hours. |
| | "Remade" whole | 26 | 6.60 | 49.7 | 4.10 | 7.48 | |
| | "Remade" skim | 29 | 6.56 | 53.9 | 0.06 | 7.81 | |
| | "Remade" buttermilk | 16 | 6.70 | 49.0 | 1.90 | 7.48 | |

scopically. The subsequent lipolysis in "remade" milks, therefore, cannot be attributed to increased surface area of milk fat as has been generally attributed in the case of homogenization of raw milk and cream. The true explanation must lie in the replacement of natural "membrane" material around fat globules. The phenomenon of hydrolysis of milk fat when an unnatural emulsifying agent is substituted for the natural fat globule adsorption "membrane" was pointed out by Tarassuk and Palmer (3). That

such treatment is conducive to lipolysis is also evident from a later report by Krukovsky and Sharp (5) on lipolysis of milk fat emulsified in pasteurized skim milk and diluted to a whole with raw skim milk. These authors chose the term "resurfacing" of fat globules to designate the presence of adsorption layer or fat globules of other composition than a natural one.

In connection with the properties of the fat globule adsorption "membrane" derived from skim milk (skim milk is used as emulsifying agent to make the synthetic cream), the lipolysis takes place in "remade" milks obtained from this cream to about the same extent as in similar milks from gelatin and acid whey powder creams. However, in spite of lipolysis, the coagulation of "remade" buttermilk from "skim milk" cream is normal and curd tension reduction is relatively only slight, as can be seen from table 2. Similar results were obtained by Tarassuk and Palmer (3) when an aqueous solution of skim milk powder was used as an emulsifying agent.

TABLE 2

*Curd tension, pH, and surface tension of "remade" milks from "skim milk" and natural fat globule "membrane" creams*

| Experiment No. | Product tested | Curd tension | pH | Surface tension at 20–21°C. |
|---|---|---|---|---|
| | | *gm.* | | *dynes per cm.* |
| IV | "Skim milk" cream | | | |
| | *Source of milk plasma: raw skim milk* | | | |
| | Original skim | 64 | 6.60 | 53.9 |
| | "Remade" whole | 58 | 6.49 | 44.8 |
| | "Remade" skim | 61 | 6.56 | 49.3 |
| | "Remade" buttermilk | 54 | 5.88 | 42.0 |
| V | "Natural fat globule 'membrane'" cream | | | |
| | (a) *Source of milk plasma: raw skim milk* | | | |
| | Original skim | 60 | 6.64 | 53.9 |
| | "Remade" whole | 39 | 6.54 | 49.0 |
| | "Remade" skim | 42 | 6.60 | 51.1 |
| | "Remade" buttermilk | 0 | 6.12 | 42.3 |
| | (b) *Source of milk plasma: pasteurized skim milk* | | | |
| | Original skim | 60 | 6.64 | 53.9 |
| | "Remade" whole | 42 | 6.62 | 50.4 |
| | "Remade" skim | 46 | 6.64 | 52.5 |
| | "Remade" buttermilk | 27 | 6.65 | 51.0 |
| VI | Natural cream | | | |
| | Whole milk (raw) | 68 | 6.58 | 49.0 |
| | Skim milk (raw) | 84 | 6.59 | 53.2 |
| | Buttermilk from raw cream | 50 | 6.53 | 44.0 |
| | Buttermilk from pasteurized cream | 48 | 6.60 | 46.9 |
| VII | Buttermilk from natural pasteurized cream | 48 | 6.59 | 47.2 |
| | Buttermilk from natural pasteurized cream + steapsin* | 0 | 5.58 | 33.6 |

* On the addition of steapsin to cream, the cream was aged until a distinct rancid flavor was developed, and then churned.

The data in table 2, experiment V, show also that the natural "membrane" material, once removed from the fat globules by churning no longer possesses, to the same extent, the property of protection from lipolysis. In experiment V fresh sweet cream was washed three times, each with four volumes of distilled water at 35° C. The washed cream was churned, and the buttermilk from washed cream, pervaporated to two-thirds of original volume, was used as emulsifying agent in preparation of a synthetic cream. This cream is designated as "natural fat globule 'membrane' " cream. The "remade" milks were made from this cream in the normal way using raw skim milk in (a) and pasteurized skim milk in (b) parts of experiment as the source of milk plasma. This skim milk was obtained from the same lot of whole milk as the washed cream.

For the sake of comparison, in the separate experiment VI, table 2, the typical curd tension, pH and surface tension data of buttermilks obtained by churning a natural fresh, raw cream and the same cream but pasteurized are given.

The additional and direct proof of the phenomenon of total inhibition of clotting of buttermilk by rennet due to lipolysis is demonstrated by the data of the experiment VII, table 2. The buttermilk obtained from cream to which steapsin has been added exhibited exactly the same properties in respect to non-coagulation with rennet, low pH and low surface tension values as the buttermilks from "remade" creams whose milk plasma was a raw skim milk. The fact and the extent of hydrolysis of fat in such creams is also shown by the amount of their free fatty acids; the data are given in table 3. The experiment numbers in this table correspond to the respective experiments of tables 1 and 2.

## II. THE EFFECT OF CERTAIN FAT ACIDS ON COAGULATION OF MILK BY RENNET

The phenomenon of inhibition of rennet clot in buttermilks from "remade" creams in which hydrolysis of fat has taken place leads to the question as to the constituent of fat affected and the mechanism involved in the prevention of clotting of buttermilk by rennet. Theoretically, the release of fat acids on hydrolysis of milk fat should cause faster coagulation of milk or buttermilk by rennet and give higher curd tension due to the lowering of pH. And, indeed, that is what happens when fatty acids of lower molecular weight, such as caproic, are added to milk in the amount necessary to lower the pH of milk comparable to the pH of "remade" buttermilks. However, the addition to milk of higher melting point fat acids, such as lauric, myristic or palmitic, inhibits the coagulation of milk by rennet completely when the conditions in respect to the amount added (as judged by the lowering of pH of milk) and aging at low temperature are comparable to those of buttermilk from "remade" creams. The complete inhibition of clotting of milk by

TABLE 3

*Free fatty acids of fat from various "remade" creams**

| Experiment No. | Description of fat | Acid degree† |
|---|---|---|
| I | Gelatin creams | |
| | Original fat (before emulsification) | 0.67 |
| | (a) Fat from "remade" cream | 5.05 |
| | Source of milk plasma: raw skim milk | |
| | (b) Fat from "remade" cream | 0.62 |
| | Source of milk plasma: pasteurized skim milk | |
| II | Whey powder creams | |
| | Fat from "remade" cream | 5.02 |
| | Source of milk plasma: raw skim milk | |
| III | Whey powder creams | |
| | Original fat (before emulsification) | 0.78 |
| | Fat from "remade" cream | 0.72 |
| | Source of milk plasma: pasteurized skim milk | |
| IV | Skim milk cream | |
| | Original fat (before emulsification) | 0.61 |
| | Fat from "remade" cream | 7.45 |
| | Source of milk plasma: raw skim milk | |
| V | Natural fat globule "membrane" creams | |
| | Original fat (before emulsification) | 0.71 |
| | (a) Fat from "remade" cream | 2.92 |
| | Source of milk plasma: raw skim milk | |
| | (b) Fat from "remade" cream | 0.75 |
| | Source of milk plasma: pasteurized skim milk | |
| VI | Natural cream | |
| | Fat from raw cream | 0.96 |
| | Fat from pasteurized cream | 0.67 |

* The "remade" creams were about 30 hours old at the time of their churning and isolation of fat for acid degree.

† ml. 1N NaOH/100 gm. fat.

these fat acids[1] is demonstrated by the data of table 4. The addition of lauric (M. Pt. 43.6° C.), myristic (M. Pt. 54° C.) and palmitic (M. Pt. 62.6°–63° C.) acids to milk necessitated melting them and adding them in a liquid state to the milk which was also warmed to the temperature of the melting point of the fat acid added. On the addition of the fat acid to milk the mixture was maintained at the melting-point temperature of the respective fat acid for an additional 20–25 minutes, with frequent vigorous stirring to assure a thorough dispersion of the acid in the milk. After this treatment the milk was cooled in ice cold water to 5–7° C. and aged at 7° C. for at least two hours before the curd tension test was made, the latter being made at 35° C.

The question naturally arises as to the mechanism by which the fat acids

[1] Fatty acids in this experiment were obtained from the following sources: Caproic—from Special Chemical Co., Waukegan, Illinois; lauric, myristic and palmitic from Eastman Kodak Co., and oleic acid was prepared by Dr. J. L. Henderson, by fractional distillation of the methyl esters of olive oil and purification by several crystallizations from acetone at – 50° C. The oleic acid had an iodine number of 88.6.

under consideration inhibit the clotting of milk by rennet and thus reduce the curd tension of milk to zero. The following experimental evidence gives some insight into the phenomenon involved. It was found that on the addition of fat acids to milk in the manner described, it is essential to cool the milk and hold cold for some period of time in order to obtain a zero curd tension. One hour of aging at 7° C. seems to be the minimum aging time necessary. When the milk + 0.3 per cent of lauric acid of experiment II, table 4 was tested immediately upon cooling to 7° C. the clotting of milk by rennet was merely delayed although the curd formed was very weak and soft. The sample of the same milk aged for 1 hour at room temperature gave a normal rennet clot; while the sample aged for 2 hours at 7° C. did not show a trace of visible coagulation on the addition of more than double the amount of rennet necessary for an instantaneous clotting of the original sample of milk.

It can be seen from the data of experiment I, table 4, that the addition of $CaCl_2$ to milk nullifies the inhibitive effect of fat acids in rennet coagulation of milk. The presence in milk of an adequate concentration of $Ca^{++}$ is essential for a normal clotting with rennet. It may be argued then that the inhibitive effect of fat acids on rennet coagulation is due to the formation of highly insoluble calcium salts of these acids. The necessity of cooling and aging in itself speaks against the argument of tying up calcium ions by formation of calcium salts of fat acids as the true explanation. Besides it is very unlikely that an appreciable amount of calcium salts of fat acids will be formed at the pH values experienced. The treatment of milk coupled with the amount and the kind of fat acids necessary in order to obtain a complete inhibition of rennet coagulation suggests an adsorption film of the fat acid on the colloidal complex involved in clotting of milk. The following experimental evidence bears out the film theory and the importance of the physical state of the film in rennet coagulation. As has been stated in the experimental methods the temperature of the milk used for curd tension determination was 35° C. If the milk or "remade" buttermilk, exhibiting a failure to clot because of the hydrolysis of fat or the direct addition of certain fat acids as has been described, is warmed to 50°–55° C., held at that temperature for about ten minutes and then cooled to 35° C., the normal clotting by rennet and the curd tension are restored. The temperature to which the milk has to be warmed previous to cooling to 35° C., at which temperature the rennet is added, depends entirely on the melting point of the fat acid involved in the inhibition of rennet coagulation. Thus, in the samples of milk in which a failure to clot was due to the addition of lauric acid, the warming to the temperature of 42–44° C. for about ten minutes is fully sufficient for a restoration of curd tension. The melting point of lauric acid is 43.6–44° C.

TABLE 4

*Effect of addition of certain fat acids to milk on curd tension, pH and surface tension of milk*

| Experiment No. | Treatment of milk | Curd tension | pH | Surface tension at 20–21° C. |
|---|---|---|---|---|
| | | *gm.* | | *dynes per cm.* |
| I | Raw skim milk (blank) | 69 | 6.66 | 53.5 |
| | Raw skim + 0.3% of laurie acid | 0 | 6.19 | 49.7 |
| | Raw skim + 0.3% of laurie acid + 1 ml. of 5% $CaCl_2 \cdot 2H_2O$ | 75 | ..... | ..... |
| | Raw skim + 0.3% of laurie acid + 2 ml. of 5% $CaCl_2 \cdot 2H_2O$ | 98 | ..... | ..... |
| II | Raw skim milk (blank) | 84 | 6.63 | 53.9 |
| | Raw skim + 0.3% of laurie acid | 0 | 6.22 | 49.0 |
| | Pasteurized skim + 0.3% of laurie acid | 0 | 6.20 | 49.0 |
| | Raw skim + 0.2% of laurie acid | 29 | 6.30 | 49.0 |
| | Raw skim + 0.1% of laurie acid | 80 | 6.42 | 49.0 |
| III | Raw skim (blank) | 73 | 6.60 | 53.5 |
| | Raw skim + 0.3% of caproic acid | 92 | 5.58 | 49.0 |
| | Raw skim + 0.3% of myristic acid | 0 | 6.07 | 51.8 |
| | Raw skim + 0.3% of palmitic acid | 0 | 6.14 | 51.8 |
| | Raw skim + 0.27% of oleic acid | 32 | 6.32 | 38.5 |

The data in table 5 illustrate the importance of physical state of fat acids involved in the inhibition of clotting of milk by rennet.

## DISCUSSION

Milks and their creams whose natural fat globule adsorption "membrane" material has been replaced by the process of re-emulsification of the milk fat in aqueous solutions of gelatin, whey powder, calcium caseinate, skim milk powder or skim milk itself, exhibit a pronounced lipolysis of fat if their source of milk plasma is raw skim milk. The use of pasteurized skim milk as the source of milk plasma prevents this lipolysis. It is evident then that a normal raw skim milk has an enzyme capable of hydrolyzing milk fat and that a natural fat globule adsorption "membrane" affords some protection from this action.

In the light of the work of Herrington and Krukovsky (6) on lipase action in normal milk and our data on the acid degree of fat from natural raw cream and the same cream pasteurized, it appears that the protection against lipolysis afforded by the natural adsorption "membrane" around fat globules is not absolute. However, in our experience, the extent of lipolysis in normal raw milk[2] is so negligible as to be of no importance from the commercial point of view unless the enzyme is activated. It is interesting to note that all processes of activation of lipase reported in the lit-

[2] The so-called bitter milk of late lactation in which rancidity develops seemingly spontaneously is excluded.

erature, such as, homogenization (7), shaking (8), and temperature manipulation (9), do lead to the disruption and partial replacement or distortion of the natural adsorption layer on fat globules. This fact gives further support to the theory of protection from lipolysis by this natural adsorption layer when it is in the state of orientation on the fat globules as exists in untreated milks. The evidence that the natural fat globule adsorption "membrane" once removed from the fat globules by churning affords less protection against lipolysis suggests the partial denaturation of protein of the fat globule "membrane" as a possible explanation. The Rahn theory of denaturation of surface-active protein material in the process of churning is also supported by the recent work of Clayton (10).

That the phenomenon of curd tension reduction or total inhibition of clotting of buttermilks from "remade" creams by rennet is due largely to hydrolysis of milk fat in "remade" creams has been amply demonstrated by the differences in curd tension obtained in the presence and the absence of hydrolysis of fat in "remade" creams, as well as, by the experiments in which the same phenomenon has been produced by a direct addition of high melting point fat acids to milk or by the addition of steapsin to cream. However, even the very extensive hydrolysis of fat in cream will not lead to a complete inhibition of clotting of buttermilk by rennet in all cases as is shown by the data on "remade" buttermilk from "skim milk" cream in table 2. Since the presence of lower molecular weight fat acids would counteract the curd tension reducing effect of high melting point fat acids it seems safe to assume that the final effect on curd tension would be determined by the amount and the kind of fat acids produced in hydrolysis of fat in a particular cream. This would indicate that the material surrounding fat globules might be a factor in selective hydrolysis by the enzyme.

The clue to the mechanism of inhibition of coagulation of milk by rennet by certain fat acids is found in the fact of the partial or complete restoration of normal properties when the milk is warmed to a sufficiently high temperature to soften or melt the fat acids. On the basis of surface tension data the adsorption of the fat acids by the calcium caseinate complex of milk would be expected. The formation by fat acids of surface films consisting presumably of single layers of oriented molecules is a well-established fact. There is a considerable difference in the packing of oriented molecules in the film depending on the physical state of the fat acid. The packing of molecules of fat acid would be much greater when the acid is in a solid state. This packing of oriented molecules in the film is seemingly great enough when the acid is in a solid state to prevent the action of rennet on calcium caseinate of milk. This explanation is supported by the work of Söhngen, Wieringa and Pasveer (11) in which some experimental evidence is given that the rennin has to be adsorbed on the casein molecule in order to be effective.

TABLE 5

*Effect of heat treatment on curd tension of milks whose rennet coagulation is inhibited by hydrolysis of milk fat or by direct addition of certain fat acids*

| Sample No. | Treatment of milk | Curd tension |
|---|---|---|
| | | *gm.* |
| 1 | Raw skim (blank). Standard procedure* | 81 |
| 2 | Raw skim + 0.3% of lauric acid. Standard procedure | 0 |
| 1(a) | Raw skim (blank). Warmed to 44° C., held at 43°–44° C. for 10 minutes and then cooled to 35° C. | 79 |
| 2(a) | Raw skim + 0.3% of lauric acid. Treated as in 1(a) | 71 |
| 3 | "Remade" skim from gelatin cream. Standard procedure | 70 |
| 4 | "Remade" buttermilk from gelatin cream. Standard procedure | 0 |
| 3(a) | "Remade" skim from gelatin cream. Warmed to 55° C. and held at 50–55° C. for 10 minutes | 67 |
| 4(a) | "Remade" buttermilk from gelatin cream. Treated as in 3(a) | 42 |
| 5 | "Remade" skim from whey powder cream. Standard procedure | 54 |
| 6 | "Remade" buttermilk from whey powder cream. Standard procedure | 0 |
| 5(a) | "Remade" skim from whey powder cream. Treated as in 3(a) | 50 |
| 6(a) | "Remade" buttermilk from whey powder cream. Treated as in 3(a) | 44 |

* Under the standard procedure rennet is added on warming the milk to 35° C.

## CONCLUSIONS

1. A replacement of the natural adsorption "membrane" of the fat globules by other surface-active material in raw milk or cream promotes an extensive lipolysis of the milk fat.

2. The rennet coagulation of buttermilk obtained by churning a natural or synthetic cream in which an extensive hydrolysis of fat has taken place may be completely inhibited. The inhibition is due to the interference of high melting point fat acids with the normal action of rennet.

3. The addition of lauric, myristic or palmitic acid to milk inhibits completely the rennet coagulation if the conditions as to the amount of the acid added and the aging of the milk in cold after the addition of acid, are satisfied.

4. The normal rennet coagulation and curd tension of milk are restored if the physical state of the fat acids involved is changed from the solid to (or near to) the liquid state.

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# EFFECT OF HUMIDITY ON MOISTURE CONTENT AND FORMS OF LACTOSE IN DRIED WHEY

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## INTRODUCTION

Dried whey contains 60 to 75 per cent of anhydrous lactose in the dry matter, depending largely upon the extent of lactose fermentation prior to drying. If whey is dried by the ordinary spray or roll drying process in the manner customarily used for milk, the lactose does not crystallize but remains in the form of a syrup or glass. Whey dried in this manner is very hygroscopic. At ordinary humidities it will absorb moisture and become sticky, and the lactose will finally crystallize, forming a hard cake which must be broken up. The role of lactose in the caking of dried whey has previously been discussed and demonstrated by Troy and Sharp (4). Several patents have been issued covering various processes for inducing lactose crystallization prior to the complete drying of whey (1).

Holm and Greenbank (2) and Supplee (3) determined the moisture content of dried milk after storage at a series of relative humidities. Troy and Sharp (4) showed that a change of beta to alpha lactose occurred on holding dried milk at a high humidity and that this change was accompanied by the appearance of alpha hydrate crystals in the dried milk. The present paper reports results obtained with dried whey. The lactose content of dried whey is higher than that of dried milk and consequently the changes in the lactose are more strikingly reflected in the behavior of the product when exposed to varying humidities. In one type of non-caking dried whey a large proportion of the lactose is present as crystalline alpha hydrate, in another, as beta anhydride. Much information in regard to the properties of lactose has been gained by a study of methods of drying and the properties of dried whey.

## EXPERIMENTAL

*Control of humidity.* Dried whey samples of 3 grams each were placed in open aluminum dishes 5 centimeters in diameter. The dishes were placed in uniform large desiccators with straight sides. In the bottom of each desiccator were placed two liters of an appropriate solution of sulphuric acid to give the desired relative humidity at 25° C. The sulphuric acid solutions were prepared according to the data given in the International Critical Tables. The dishes were weighed at the end of ¼, 1, 3, 5, 15, 21, 34, and 68 days.

Other experiments have shown that several years may be required for

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the complete adjustment of the samples to some of the humidity levels. However, for ordinary practical purposes the adjustment of the moisture content of the samples is fairly complete in one to three weeks.

*Types of dried whey.* The samples of dried whey studied divided themselves roughly into two groups, depending on whether alpha lactose hydrate or beta anhydride had crystallized to form an appreciable amount of solid phase.

The sample numbers followed by the letter "S" refer to samples prepared by the authors, using small scale manufacturing equipment; otherwise, the samples were from commercial products obtained from various sources.

The process of drying whey in which beta lactose crystallizes as a solid phase was developed by Lavett and is essentially as follows: Whey is first concentrated by evaporation to between 30 and 50 per cent solids. The whey is further concentrated to about 80 or 85 per cent total solids on double atmospheric rolls rotating outward from the pinch. The taffy-like mass removed by the knives drops on the surface of a second pair of double atmospheric rolls placed directly beneath the first pair but turning inward toward the pinch. The mass is continuously seeded with beta crystals adhering to the roll surface and the drying is completed on this second pair of rolls. The dry product removed by the knives is flaky and easily pulverized, and a large part of the lactose is present as beta crystals.

The following processes induce lactose crystallization as the alpha lactose hydrate:

(a) In the Simmons process whey is concentrated to between 60 and 70 per cent solids by evaporation. This concentrated syrup is drawn into crystallizing vats. The cooled mass may be mixed with a portion of whey from a preceding lot, or even with dried whey, in order to seed the mass with alpha hydrate crystals. This mixture is allowed to set for some hours, permitting a considerable amount of alpha lactose hydrate to crystallize. After this setting period the material is broken up into small particles and drying is completed by warmed air.

(b) In the Peebles and Manning process whey is concentrated to between 30 and 50 per cent solids, and sprayed into a conical dryer. The spray drying is so controlled that the whey is not completely dried. The product is then mixed and introduced into a rotating drum, together with a little moisture in the form of steam. The temperature and moisture content are so adjusted as to induce crystallization of the lactose as alpha hydrate. Drying is then completed by air.

(c) Whey is concentrated to 60 per cent solids and is then agitated in a crystallizing vat, preferably with seeding from a previous lot. After a considerable amount of lactose has crystallized and the material has thickened to a very considerable extent, drying and crystallization are completed on

rolls in a vacuum; the rolls are maintained at an interior temperature between 140° and 170° F. In this way, with the completely seeded mass applied to the roll and the temperature maintained well below the so-called inversion point of lactose, drying accompanied by crystallization of the lactose as alpha hydrate is accomplished.

(d) Whey was concentrated by various methods in small plant equipment. Crystallization of lactose as alpha hydrate occurred spontaneously or was induced by seeding. Drying was completed on trays in a drying tunnel.

*Results.* Figure 1 shows that the adjustment of the moisture content of small samples of dried whey placed at various relative humidities is approximately complete in one to three weeks. Two typical samples of dried whey are illustrated; in one, a considerable amount of the lactose was pres-

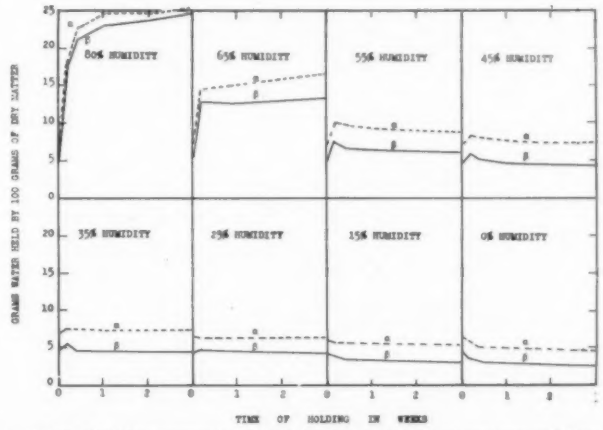


FIG. 1. Water-holding capacity of dried whey at 25° C. at various relative humidities. In one case alpha hydrate, in the other, beta anhydride is present as the solid phase.

ent as crystalline alpha hydrate, in the other, as crystalline beta anhydride. These samples were sealed by the manufacturer and were received in air-tight containers. Figure 1 indicates that whey is dried commercially to the extent of being in equilibrium with a relative humidity of approximately 20 to 25 per cent at room temperature.

A number of samples of whey dried by the various methods were tested in order to determine the variations among samples. Some of the data obtained are presented in table 1. It will be observed that the samples roughly divide themselves into two groups. The samples containing beta lactose as a solid phase tended to contain less moisture when exposed to humidities below 65 per cent than samples containing alpha lactose hydrate as a solid phase exposed to the same relative humidities. This would be

TABLE 1

*Grams of water held by 100 grams of dry matter in dried wheys kept at various relative humidities for three weeks at 25° C.*

| Sample No. | Lactose | | | Relative humidity at 25° C. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total in solids | Proportion of | | 95%* | 80% | 65% | 55% | 45% | 35% | 25% | 15% |
| | | Alpha | Beta | | | | | | | | |
| | % | % | % | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* |
| **Beta lactose solid phase, concentrated, atmospheric drum dried** | | | | | | | | | | | |
| 28 | 62.8 | 21.0 | 79.0 | 58.0 | 25.2 | 12.7 | 6.6 | 5.3 | 4.8 | 4.5 | 3.5 |
| 70 | 71.9 | 25.5 | 74.5 | 50.8 | 18.8 | 11.7 | 4.5 | 3.4 | 3.0 | 4.0 | 2.9 |
| 71 | 69.0 | 18.4 | 81.6 | 61.6 | 24.7 | 14.7 | 6.1 | 4.5 | 4.4 | 4.2 | 3.4 |
| 36 | 67.6 | 19.6 | 80.4 | 63.0 | 24.3 | 13.2 | 6.1 | 4.8 | 4.4 | 4.1 | 3.2 |
| **Alpha lactose solid phase concentrated, seeded, then air dried** | | | | | | | | | | | |
| 67 | 69.9 | 92.0 | 8.0 | 62.3 | 24.2 | 16.3 | 8.9 | 7.7 | 7.5 | 6.4 | 5.6 |
| 22 | 68.1 | 90.1 | 9.9 | 76.0 | 31.7 | 15.4 | 8.0 | 7.2 | 6.6 | 5.5 | 4.9 |
| 26 | 60.1 | 97.3 | 2.7 | 82.5 | 28.6 | 20.6 | 10.5 | 8.7 | 8.1 | 7.0 | 6.2 |
| **Alpha lactose solid phase concentrated, spray dried, air dried** | | | | | | | | | | | |
| 49 | 68.2 | 89.7 | 10.3 | 52.9 | 24.5 | 14.9 | 9.4 | 8.5 | 8.2 | 7.4 | 6.7 |
| 73 | 67.7 | 88.4 | 11.6 | 60.3 | 25.0 | 15.0 | 10.0 | 8.6 | 8.2 | 7.6 | 7.0 |
| **Alpha lactose solid phase concentrated, seeded, vacuum drum dried** | | | | | | | | | | | |
| 18 | 67.3 | 91.7 | 8.3 | 60.6 | 31.0 | ..... | 7.9 | ..... | 6.7 | 6.0 | 5.0 |
| 28 | 71.6 | 55.0 | 45.0 | 58.4 | 30.1 | ..... | 7.5 | ..... | 6.4 | 6.1 | 5.2 |
| **Alpha lactose solid phase, various methods of concentrating and air drying** | | | | | | | | | | | |
| 108 | 63.0 | 93.2 | 6.8 | 74.5 | 31.3 | 22.1 | 11.4 | 10.9 | 10.9 | 10.8 | 6.6 |
| 168 | 74.5 | 91.4 | 8.6 | 51.0 | 21.2 | 10.4 | 7.1 | 6.4 | 6.2 | 5.6 | 5.0 |
| 418 | 72.4 | 92.5 | 7.5 | 44.4 | 17.5 | 12.1 | 8.7 | 7.8 | 7.6 | 6.8 | 6.4 |
| 478 | 70.8 | 90.0 | 10.0 | 48.9 | 20.2 | 12.6 | 8.8 | 8.1 | 7.8 | 7.0 | 6.2 |
| 718 | 69.0 | 88.0 | 12.0 | 64.9 | 27.8 | 18.9 | 11.0 | 9.5 | 9.1 | 7.9 | 7.2 |

* 7 to 14 days.

expected since the molecule of water which forms part of the alpha hydrate crystal is removed in the moisture determinations, and consequently in table 1 is reported as a part of the moisture content or non-dry matter content. The relative proportions of alpha and beta lactose in the samples given in table 1 represent the composition at the start of the experiment. They were determined from the initial and final (equilibrium) rotations of an extract, clarified with alcoholic mercuric chloride and decolorized with norrit. Total lactose was determined from the final rotation, sample weight and dilution (5).

Figure 2 shows the relationship between relative humidity and moisture-holding power of two typical dried wheys. Large amounts of moisture are

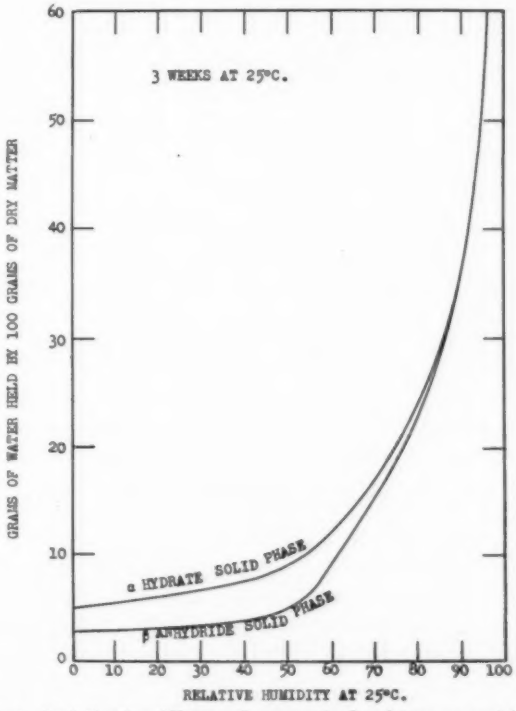


FIG. 2. Effect of relative humidity on the amount of moisture present in dried whey.

not absorbed by stabilized dried whey until the relative humidity exceeds 50 per cent. Table 2 gives the moisture content of a series of additional samples of dried whey when held at different relative humidities for one week and includes the humidity range between 80 and 95 per cent. Samples containing beta lactose as a solid phase contained less water than did sam-

TABLE 2

*Grams of water associated with 100 grams of dry matter in wheys held at various relative humidities for one week at 25° C.*

| Relative humidity | α hydrate solid phase | | | | | β lactose solid phase | |
|---|---|---|---|---|---|---|---|
| | α seeded vac. roll dried | | α seeded tray dried | | | Atm. drum dried | |
| | | | Old sample | Fresh samples | | Flakes ground | From flakes |
| | A | B | C | D | E | F | G |
| % | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* |
| 95 | 60.6 | 58.4 | 52.2 | 59.1 | 52.3 | 42.3 | 43.3 |
| 90 | 47.1 | 45.9 | 35.8 | 44.1 | 42.4 | 31.7 | 32.5 |
| 85 | 37.4 | 35.9 | 27.4 | 34.3 | 33.5 | 24.7 | 25.9 |
| 80 | 30.0 | 30.5 | 23.5 | 29.4 | 28.3 | 20.6 | 21.0 |
| 55 | 8.4 | 8.0 | 8.5 | 9.0 | 8.8 | 6.2 | 6.2 |
| 35 | 6.8 | 6.6 | 6.9 | 7.1 | 6.9 | 4.4 | 4.4 |
| 25 | 6.0 | 6.1 | 6.2 | 6.1 | 6.1 | 5.1 | 5.2 |
| 15 | 5.1 | 5.3 | 5.9 | 5.7 | 5.7 | 4.3 | 4.3 |
| 0 | 4.8 | 4.0 | 5.0 | 4.5 | 4.5 | 3.1 | 3.2 |
| 0* | 3.9 | 2.6 | 4.8 | 3.8 | 3.8 | 2.6 | 2.7 |

* Over concentrated sulfuric at end of 62 days.

ples containing alpha lactose hydrate as a solid phase. Grinding the sample had little or no effect on moisture absorption. After standing a number of weeks at humidities of 65 per cent and higher there is little difference in moisture content of wheys dried by various methods.

The effect was studied of maintaining the relative humidity constant at 55 per cent but varying the temperature. Results obtained with a series of typical samples are given in table 3. Temperature does not exert a very marked effect upon the equilibrium moisture content of the samples when exposed to a constant humidity. Apparently it does affect the rate of moisture equilibration. The samples maintained at 45° C. had darkened very much by the time the experiment was concluded.

*Effect of relative humidity upon the proportions of alpha and beta lactose.* The lactose in the various samples of dried whey as freshly prepared by the procedures discussed in this paper is present largely in the crystalline form either as alpha hydrate or as beta anhydride, but a portion, unable to crystallize because of the speed of drying, remains in the glassy state as a mixture of uncrystallized alpha lactose and uncrystallized beta lactose. If the moisture content of the dried whey is maintained at a low value, the lactose remains for long periods of time in an unchanging condition. But if the dried whey is permitted to absorb moisture, as when held at humidities between 30 and 50 per cent and the glass is sufficiently diluted to permit the movement of molecules, the particular solid form of lactose present continues to crystallize slowly, be it alpha hydrate or beta anhydride. Mutarotation takes place simultaneously to compensate for the corresponding

TABLE 3

*Grams of water held by 100 grams of dry matter in dried whey after various periods of holding at 55 per cent relative humidity at 2, 25, and 45° C.*

| Number of days held | Beta type | | | | Alpha type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28 | 70 | 71 | 36 | 67 | 22 | 26 | 49 | 73 | 108 | 168 | 418 | 478 | 718 |
| | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* | *gm.* |
| 45° C. (113° F.) | | | | | | | | | | | | | | |
| 0 | 4.5 | 3.6 | 4.5 | 4.3 | 6.7 | 5.4 | 7.1 | 7.6 | 10.8 | 7.8 | 5.1 | 7.1 | 7.1 | 8.1 |
| 1 | 7.4 | 4.7 | 7.1 | 6.9 | 9.7 | 8.7 | 11.5 | 10.6 | 10.9 | 12.9 | 7.3 | 8.7 | 9.0 | 11.6 |
| 3 | 7.4 | 4.5 | 6.7 | 6.6 | 9.2 | 8.5 | 11.2 | 10.2 | 10.8 | 12.5 | 7.2 | 8.7 | 8.8 | 11.5 |
| 7 | 6.4 | 4.2 | 6.2 | 6.2 | 8.7 | 8.0 | 11.0 | 9.7 | 10.0 | 11.7 | 7.0 | 8.4 | 8.5 | 11.2 |
| 14 | 5.9 | 4.4 | 5.8 | 5.9 | 8.4 | 7.8 | 10.2 | 9.3 | 9.6 | 11.5 | 7.0 | 8.3 | 8.3 | 10.9 |
| 21 | 5.5 | 4.6 | 5.6 | 5.6 | 8.3 | 7.7 | 9.8 | 8.8 | 9.2 | 10.5 | 6.9 | 8.3 | 8.3 | 10.7 |
| 25° C. (77° F.) | | | | | | | | | | | | | | |
| 0 | 4.5 | 3.6 | 4.5 | 4.3 | 6.7 | 5.4 | 7.1 | 7.6 | 10.8 | 7.8 | 5.1 | 7.1 | 7.1 | 8.1 |
| 1 | 7.8 | 5.2 | 7.3 | 7.4 | 9.9 | 9.0 | 11.1 | 10.6 | 10.4 | 12.2 | 7.5 | 9.1 | 9.6 | 11.6 |
| 3 | 7.4 | 4.8 | 7.2 | 6.9 | 9.5 | 8.8 | 11.0 | 10.3 | 10.4 | 12.1 | 7.3 | 8.9 | 9.3 | 11.4 |
| 7 | 7.0 | 4.5 | 6.4 | 6.5 | 9.2 | 8.0 | 10.7 | 10.0 | 10.1 | 11.6 | 7.1 | 8.7 | 8.9 | 11.1 |
| 14 | 6.7 | 4.4 | 6.2 | 6.2 | 9.0 | 8.0 | 10.5 | 9.5 | 10.0 | 11.4 | 7.0 | 8.6 | 8.7 | 11.0 |
| 21 | 6.6 | 4.5 | 6.1 | 6.1 | 8.9 | 8.0 | 10.5 | 9.4 | 10.0 | 11.4 | 7.1 | 8.7 | 8.8 | 11.0 |
| 2° C. (34° F.) | | | | | | | | | | | | | | |
| 0 | 4.5 | 3.6 | 4.5 | 4.3 | 6.7 | 5.4 | 7.1 | 7.6 | 10.8 | 7.8 | 5.1 | 7.1 | 7.1 | 8.1 |
| 1 | 8.0 | 6.1 | 7.2 | 7.7 | 8.4 | 7.9 | 9.4 | 9.4 | 9.4 | 10.0 | 7.2 | 8.3 | 8.7 | 10.0 |
| 3 | 8.2 | 7.2 | 7.6 | 8.0 | 8.9 | 8.5 | 10.0 | 9.7 | 9.4 | 11.0 | 7.4 | 8.5 | 9.1 | 10.6 |
| 7 | 7.5 | 5.5 | 6.9 | 7.2 | 9.1 | 8.4 | 10.2 | 9.7 | 9.4 | 11.1 | 7.2 | 8.5 | 9.1 | 10.7 |
| 14 | 7.2 | 4.6 | 6.4 | 6.7 | 9.0 | 8.4 | 10.3 | 9.6 | 9.4 | 11.1 | 7.2 | 8.5 | 9.1 | 10.6 |
| 21 | 7.0 | 4.5 | 6.2 | 6.5 | 9.0 | 8.5 | 10.3 | 9.6 | 9.4 | 11.1 | 7.2 | 8.5 | 9.1 | 10.5 |

depletion in the glass, a disturbance of equilibrium. Evidence that this change has occurred is found in the altered relative proportions of beta and alpha lactose as well as in the absorption and subsequent liberation of moisture at constant relative humidity.

TABLE 4

*Percentage of total lactose in the alpha form after holding 3 weeks at 25° C. at various relative humidities*

| Sample No. | Relative humidity at 25° C. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 95* | 80 | 65 | 55 | 45 | 35 | 25 |
| | % | % | % | % | % | % | % |
| **Beta solid phase, concentrated, atmospheric drum dried** | | | | | | | |
| 28 | 86.5 | 95.4 | 41.3 | 7.0 | 7.7 | 9.1 | 14.6 |
| 70 | 86.0 | 95.1 | 93.8 | 12.7 | 11.5 | 12.9 | 19.6 |
| 71 | 84.3 | 94.3 | 81.2 | 7.2 | 7.2 | 10.3 | 14.0 |
| 36 | 84.8 | 92.4 | 46.0 | 6.0 | 9.4 | 8.0 | 13.3 |
| **Alpha solid phase, concentrated, seeded, air dried** | | | | | | | |
| 67 | 72.9† | 88.8† | 92.0 | 94.4 | 93.4 | 90.5 | 90.5 |
| 22 | 79.0 | 93.5 | 95.5 | 93.2 | 90.5 | 88.2 | 87.0 |
| 26 | 75.8 | 83.3† | 92.9 | 97.2 | 95.9 | 91.9 | 90.5 |
| **Alpha solid phase, concentrated, spray dried, air dried** | | | | | | | |
| 49 | 85.3 | 92.4 | 93.4 | 93.4 | 91.0 | 88.5 | 88.9 |
| 73 | 82.4 | 89.1 | 91.8 | 91.0 | 84.5 | 87.7 | 88.8 |
| **Alpha solid phase, various methods of concentrating and air drying** | | | | | | | |
| 108 | 71.4 | 91.4† | 92.0 | 98.2 | 93.0 | 92.1 | 87.4 |
| 168 | 86.0 | 91.6† | 93.9 | 94.9 | 90.9 | 91.5 | 87.2 |
| 418 | 89.4 | 94.6 | 92.6 | 91.7 | 90.9 | 91.6 | 87.9 |
| 478 | 84.2 | 94.6 | 93.2 | 90.6 | 90.4 | 87.7 | 86.1 |
| 718 | 85.2 | 92.5 | 91.3 | 89.0 | 90.9 | 88.4 | 88.0 |

* Held 2 weeks.
† Mold.

Table 4 gives in per cent that fraction of the total lactose existing as the alpha form in the samples, at the end of the experiment presented in table 1. Table 4 shows that at about 50 per cent relative humidity and 25° C. additional alpha hydrate crystallized in those samples containing alpha hydrate as the solid phase, and additional beta anhydrate crystallized in those samples containing beta lactose as solid phase. The proportions of alpha and beta lactose in the dried whey after holding at 50 per cent humidity were altered. They were altered in a direction corresponding either to crystallization of alpha hydrate, or of beta anhydride, the direction depending on the solid form present. This is indicated by a comparison with the original product or the product held at 25 per cent humidity for the same length of time.

The original analyses for some of the samples do not agree very well with those obtained from corresponding aliquots held at 25 per cent relative humidity. The direction of the discrepancy suggests that some of the samples had accidentally become exposed to moisture in the interval between the original analysis and placing aliquots in the humidity jars.

At higher humidities of 65 and 80 the dilution of the dried whey containing crystals of the beta type was such as to permit alpha lactose hydrate crystals to form. Since alpha lactose hydrate is far less soluble at 25° C. than is beta lactose, conversion of the solid beta lactose anhydride proceeded, through solution, to alpha lactose hydrate. At 95 per cent humidity the amount of moisture held by the whey was so great that an appreciable amount of lactose dissolved in the water. Therefore, the amount in the form of alpha lactose decreased again because crystalline alpha hydrate dissolved to form a relatively large amount of equilibrium solution. Table 5 shows that at 55 per cent relative humidity additional crystallization of lactose occurred more rapidly the higher the temperature, even though the results may appear to be a little uncertain at 45° C. because of difficulty in

TABLE 5

*Percentages of total lactose in the alpha form after holding for 3 weeks at 55 per cent relative humidity at various temperatures*

| Sample No. | Relative humidity 55 per cent | | |
|---|---|---|---|
| | 2° C. 34° F. | 25° C. 77° F. | 45° C. 113° F. |
| | % | % | % |
| **Beta solid phase, concentrated, atmospheric drum dried** | | | |
| 28 | 11.0 | 7.0 | 5.8 |
| 70 | 15.4 | 12.7 | 6.4 |
| 71 | 10.0 | 7.2 | 4.4 |
| 36 | 11.4 | 6.0 | 6.8 |
| **Alpha solid phase, concentrated, seeded, air dried** | | | |
| 67 | 91.3 | 94.4 | 92.4 |
| 22 | 88.4 | 93.2 | 96.8 |
| 26 | 93.1 | 97.2 | 96.2 |
| **Alpha solid phase, concentrated, spray dried, air dried** | | | |
| 49 | 89.2 | 93.4 | 95.5 |
| 73 | 86.8 | 91.0 | 95.6 |
| **Alpha solid phase, various methods of concentrating and air drying** | | | |
| 10S | 91.9 | 98.2 | 99.6 |
| 16S | 90.6 | 94.9 | 92.4 |
| 41S | 91.1 | 91.7 | 94.6 |
| 47S | 88.6 | 90.6 | 95.0 |
| 71S | 87.0 | 89.0 | 92.4 |

analyzing some of the dark products formed at this temperature. Faster crystallization at higher temperatures occurred in both alpha and beta lactose wheys. This variation in crystallization accounts for some of the variations in moisture content of the whey in table 3.

When either dried whey or dried milk containing lactose in the form of glass is exposed to a relative humidity in the neighborhood of 50 per cent, the product at first takes up moisture to dilute the glass, and then as lactose crystallizes and the vapor tension increases moisture is released again. Consequently, there is observed an increase followed by a decrease in moisture content of the samples (3, 4). Table 3 shows that this change occurs more rapidly at higher temperatures, and table 5 presents the evidence of crystallization as reflected by the change in relative proportions of the forms of lactose.

*Effect of amount of lactose in the dry matter.* In the course of this work a considerable number of samples containing varying percentages of lactose in the dry matter were allowed to come to equilibrium with atmospheres of several constant relative humidities. Figure 3 shows that the lower the percentage of lactose in the dry matter, the higher the moisture content of the dried whey when exposed to an atmosphere of constant relative humidity. This figure also indicates that differences between moisture contents of dried wheys exposed to constant relative humidity are greater, the higher the relative humidity. At lower humidities samples containing beta lactose as a solid phase arrange themselves into one group, and those containing alpha lactose hydrate as a solid phase arrange themselves into another group having higher moisture content. This difference between the two types of samples is maintained up to relative humidity in the neighborhood of 65 per cent. Above this relative humidity there is only one group for the reason that at the high relative humidities the solid beta lactose disappears and is converted to solid alpha lactose hydrate. Thus all samples are very much alike in solid lactose phase.

Commercially, the main variation in lactose content of the dry matter results from varying degrees of fermentation of the sugar prior to drying. Wheys produced by mineral acid precipitation or rennet coagulation of the casein in fresh skim milk tend to be relatively high in lactose whereas cheese wheys tend to be low because of the fermentation of the lactose prior to drying. Lactic acid is the main fermentation product and we would expect the hygroscopic properties of such dried whey to be more pronounced because one molecule of osmotically active lactose would be converted into four molecules of osmotically active lactic acid. This probably accounts for the greater hygroscopicity of the dried wheys containing the lower percentages of lactose in the dry matter.

## SUMMARY

1. Dried wheys in which crystalline beta lactose is present as a solid phase contain less water when in equilibrium with an atmosphere of con-

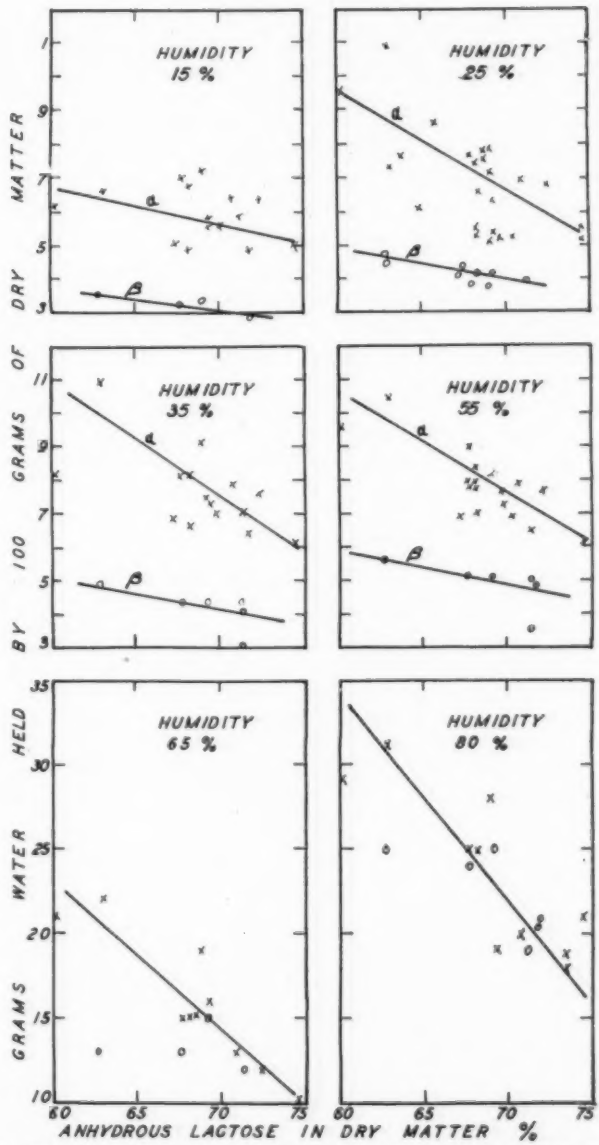


FIG. 3. The effect of percentage of lactose in the dry matter upon the moisture content of dried whey when exposed to various atmospheres of constant relative humidity at 25° C.

stant relative humidity below 65 per cent than do dried wheys in which alpha hydrate is the solid phase. The difference is largely accounted for by the molecule of water of crystallization present in the alpha hydrate crystals.

2. Stabilized dried wheys do not absorb excessive amounts of water until the relative humidity exceeds 40–50 per cent.

3. Temperature exerts no marked effect upon the equilibrium moisture content of samples exposed to constant relative humidity. The equilibrium is attained more rapidly at the higher temperatures.

4. If an appreciable amount of lactose in the glass state is present at relative humidities between 30 to 50 per cent the whey will first absorb and then reject water. This process is accompanied by the crystallization of the solid form of lactose present. In this way crystallization of beta lactose at room temperatures may occur.

5. At relative humidities of 65 per cent and above the crystalline beta lactose in dried wheys undergoes conversion to crystalline alpha hydrate.

6. The lower the percentage of lactose in the dry matter the greater the equilibrium moisture content of the dried whey at constant relative humidity.

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# THE EFFECT OF CURD TENSION OF MILK ON THE UTILIZATION OF ADDED VITAMIN D

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The fortification of milk with vitamin D concentrates has been practiced for some time. At first no question arose as to the possibility of the effectiveness of the added vitamin D varying with the type of milk fortified since practically all milk so treated was of the ordinary pasteurized variety. After the introduction of soft curd and homogenized milk and the presentation of some evidence that digestibility or calcium assimilation or both might be favorably affected by such processing (1–5), the effectiveness of vitamin D additions to such milk seemed worthy of consideration.

A supply of mixed milk was divided into three portions and prepared as follows: 1, untreated; 2, homogenized at 2500 pounds pressure and; 3, mineral modified (6, 7).[1] All three samples were then pasteurized at 143° F. for 30 minutes. A batch of natural soft curd milk was collected from selected cows in the Ohio State University herd and similarly pasteurized. Similar batches of milks were prepared at weekly intervals.

After each batch of milk was prepared the curd tension was determined by the tentative method adopted by the Committee on Curd Tension Measurements at the June, 1938, meeting of the American Dairy Science Association. Each batch was then fortified to the extent of 400 U.S.P. units of D per quart by adding a commercial vitamin D concentrate (Cream Vitex).

The samples thus prepared were fed to rats according to the official method for determining vitamin D by the line-test procedure and also by the prophylactic procedure which uses bone ash as a criterion.

## RESULTS

The curd tension measurements are summarized in table 1. Both surface and below surface readings were made but only the maximum or surface measurement is recorded, in keeping with the Curd Tension Committee's recommendation. Each value listed is the average of two or more readings. It will be seen from table 1 that the curd tension variation was considerable, from 0.0 grams in the mineral modified milk to 54.9 grams in the normal pasteurized milk. It is also interesting to note that homogenization at 2500 pounds pressure reduced the curd tension by 61.5 per cent.

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[1] Base-exchange method; prepared through the courtesy of M. and R. Dietetic Laboratories, Columbus, Ohio.

TABLE 1

*Curd tension of normal pasteurized milk, homogenized milk, mineral modified soft-curd milk, and natural soft-curd milk*

| Batch | Normal pasteurized milk | Homogenized milk | Mineral modified soft curd milk | Natural soft curd milk |
|---|---|---|---|---|
| | *gm.* | *gm.* | *gm.* | *gm.* |
| 1 | 51.5 | 21.0 | 0 | 35.5 |
| 2 | 43.5 | 15.0 | 0 | 46.0 |
| 3 | 50.0 | 27.0 | 0 | 29.0 |
| 4 | 62.5 | 27.0 | 0 | 35.0 |
| 5 | 69.0 | 22.0 | 0 | 34.5 |
| 6 | 56.5 | 17.0 | 0 | 25.5 |
| 7 | 50.0 | 23.5 | 0 | 32.0 |
| Av. | 54.9 | 21.8 | 0 | 33.9 |

In the curative trial (line test procedure), the results of which are reported in table 2, 6.0 cc. of each kind of milk were fed over a period of 3 days. The rats were slaughtered on the eighth day, they having had meanwhile free access to the basal rickets-producing diet. One group of rats received 26 milligrams of reference cod liver oil (2.5 units), an amount of vitamin D calculated to equal that in 6.0 cc. of milk. That the responses from the milks were greater than from the reference oil may have been due to the fact that the milks contained not only the added 400 units per quart but the vitamin D originally present, even though this amount was not sufficient to produce a response when 6.0 cc. each of the normal unfortified and normal soft curd unfortified milks were fed.

From the healing responses obtained when equal amounts of the various fortified milks were fed (table 2) it is apparent that there was no difference in the effectiveness of the added vitamin D. The slight differences in the average line test values are too small to be of significance.

TABLE 2

*Comparison of line test responses (healing) obtained by fortifying different kinds of milk with 400 U.S.P. units of vitamin D per quart*

| Material fed | Total amount fed | No. of rats | Line test* response |
|---|---|---|---|
| Normal milk, fortified | 6.0 cc | 10 | 1.70 |
| Homogenized milk, fortified | 6.0 cc. | 10 | 1.60 |
| Mineral modified milk, fortified | 6.0 cc. | 9 | 1.72 |
| Natural soft curd milk, fortified | 6.0 cc. | 9 | 1.78 |
| Reference cod liver oil | 2.5 U.S.P. units | 10 | 1.45 |
| Normal milk, unfortified | 6.0 cc. | 5 | 0.0 |
| Normal soft curd milk, unfortified | 6.0 cc. | 3 | 0.0 |

* The numerical line test responses were obtained by assigning the following values to degrees of healing:

−= 0.0
+−= 0.5
+= 1.0
++−= 1.5
++= 2.0
+++−= 2.5
+++= 3.0

In the prophylactic trial the rats in all but two groups were fed 2.7 cc. daily for four weeks of one of the fortified milks while having free access to the basal rickets-producing diet. The rats in one of the remaining groups each received daily 1.1 U.S.P. units of vitamin D from reference cod liver oil. This amount of vitamin D was calculated to be equivalent to the amount contained in 2.7 cc. of 400-unit milk. The final group of rats received only the basal diet.

At the end of 4 weeks the rats were killed. The femurs were removed and the bone ash determined on a fat free, moisture free basis.

TABLE 3

*Comparison of calcification (bone ash) obtained by fortifying different kinds of milk with 400 U.S.P. units of vitamin D per quart (4-week prophylactic trial)*

| Material fed | Amount fed daily | No. of rats | Gain in weight | Bone ash |
|---|---|---|---|---|
| | | | *gm.* | % |
| Normal milk, fortified | 2.7 cc. | 10 | 41.5 | 46.17 |
| Homogenized milk, fortified | 2.7 cc. | 10 | 41.3 | 46.37 |
| Mineral modified milk, fortified | 2.7 cc. | 10 | 41.3 | 45.68 |
| Natural soft curd milk, fortified | 2.7 cc. | 10 | 39.6 | 45.99 |
| Reference cod liver oil | 1.1 U.S.P. units | 9 | 18.4 | 43.02 |
| Basal diet only | ad lib | 7 | 19.1 | 27.87 |

The results of the prophylactic trial (table 3) substantiate those obtained by the curative procedure in that no significant differences were found between the bone ash values of the groups fed the fortified milks.

## DISCUSSION

In keeping with previous evidence, the data in table 1 demonstrate the curd tension-reducing effect of mineral modifying (base-exchanging) and homogenizing milk. If certain beneficial effects, such as greater digestibility, lower stomach-emptying time and increased efficiency of calcium utilization result because of such processing, as has been claimed, it might be inferred that each individual constituent was likewise benefited. That added vitamin D showed no difference in utilization may have been due to the fact that such addition did not become an intimate part of the colloid but remained a separate phase.

Although the vitamin D additions were made after the milks had been processed, a survey of a number of large plants showed that as many plants made the vitamin D addition after homogenizing as before. In preparing mineral-modified milk the usual procedure is to process over the zeolite bed before the vitamin D addition is made. In the case of natural soft curd milk the addition would, of course, be made as in other unprocessed milks

It would seem, therefore, that no claim can legitimately be made as to any merit for fortifying soft curd milks with vitamin D greater than that existing for similar additions to milk of normal curd tension.

It might be presumed that the curative trial was a measure of vitamin D *per se* and that the prophylactic trial measured not only vitamin D but calcification. It is known that lactose improves calcium utilization (8) and the higher bone ash values in the fortified milk groups than in the reference oil groups are probably accounted for by this plus the effect of the vitamin D originally present. Furthermore, a normal bone ash can be obtained by feeding an adequate amount of vitamin D in oil. This would seem to obviate the argument that in the prophylactic trial even though the mineral modified milk contained about 20 per cent less calcium than the other milks (6) calcification was just as great and therefore the calcium was more efficiently used.

## SUMMARY AND CONCLUSIONS

Normal milk, homogenized milk and mineral modified soft curd milk, all from the same source, and natural soft curd milk were pasteurized and fortified to the extent of 400 U.S.P. units of vitamin D per quart. These milks varied in curd tension from 0.0 grams for the mineral modified milk to 54.9 grams for the normal milk. Bioassays of these fortified milks by the line test procedure resulted in the same degree of healing when equal amounts of each were fed. In a prophylactic trial equal intakes of the fortified milks resulted in almost identical bone ash values.

It is concluded that the effectiveness of added vitamin D is not influenced by the curd tension of milk.

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# EFFECTS WHICH SELECTION OF DAMS MAY HAVE ON SIRE INDEXES*

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## INTRODUCTION

Several studies (1, 2, 3, 4, 5, 8) have shown that when the mates of a bull are divided into a high group and a low group on the basis of their own records, the average difference between the daughters of the two groups is less than half the difference between the two groups of dams. For example in Edwards' study (3) where the mates of each of 23 bulls were divided into a high half and a low half on the basis of the mate's own milk record, the low half averaged 7,513 and the high half 10,369, a difference of 2,856 pounds. But the daughters of these two groups averaged 7,835 and 8,427, a difference of only 592 pounds, which is barely one-fifth the difference between the two groups of dams.

If offspring were always mid-way between the phenotypes of their parents regardless of how the parents were selected, or if the offspring deviated individually from that only in a random way, the average difference between two groups of daughters by the same sire would tend to be half as large as the average difference between their dams (9). It is clear that the difference between the daughters is not this large when the dams are separated into high and low groups on the basis of the very same past records which are then used to represent those dams. What does this reveal about the inheritance of differences in milk and fat production? Does it disprove, as some have inferred, the validity of the widely used sire index which sets the breeding value of the sire as equal to twice the average of his daughters minus the average of his mates? What precautions should be taken to discount the effects of selection of dams when using indexes or other data to guide breeding choices in an actual dairy population?

In a qualitative way the answers to those questions are partly known already from the simple statistical principles for estimating a cow's real ability[1] from records of her past production. That a cow's record and her real ability are not always identical is well known from the fact that the intra-herd correlation between different single records made by the same cow, when standardized for age and times milked per day, has in most studies been something of the order of +.3 to +.4, rarely going as high as

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[1] By "real ability" is meant what the cow is most apt to produce in any future lactation when she is kept under conditions *intended to be* the same as those under which the past record was made.

+.5 except in herds where the data extended over a time long enough to permit trends in management or in the genetic level of the herd to become important.

In unselected populations each cow is as likely to have had better-than-average environment as she is to have had worse-than-average environment. Therefore, in unselected populations the discrepancies between record and real ability are random. The plus discrepancies tend to cancel the minus ones and the average record of that population tends to equal (with some sampling error, of course, which may be large where the number of cows is small) the average ability of those cows under the average environmental conditions prevailing in that population.

But when a group of cows are selected because their past records were high, one tends to get not only cows which were above average in real ability but also cows which during those past lactations were exposed to better-than-average individual environment. If such selected cows are then kept for another lactation, whatever superiority in their former records was due to their superiority in real ability will tend to appear again but the cows will be exposed to a fresh sample of intra-herd variations in environment. So far as these environmental variations are temporary and random from lactation to lactation for the same cow, they are as likely to be minus as plus in the next lactation. Therefore, the average of the future records of a selected group of cows tends (with sampling errors, of course) to equal the average of their real abilities, but to be lower than the average of the records on which they were selected.

Similarly, when a group of cows is selected because their past records were low, the selection is for a result which may have been caused either by poor ability of the cow or by her having been subject to worse-than-average environment or by both. The average real ability (the average future records) of such a group will not be as low as the average of the records on which they were put in this low group.

Thus in the example cited from Edwards, the "high" cows and the "low" cows differed by 2,856 in the average of the records on which they were divided. But if in his data the repeatability was +.5 (the fraction to be used here would be higher than the usual repeatability of single records, because he used averages where a cow had more than one lactation), then the most probable difference between the real abilities of his two groups of cows would have been 1,428 and the expected difference between the two groups of daughters would have been 714, which is not vastly different from the actual 592. An r of .455, which is well in line with usual values, would have made the expected difference exactly what the actual difference was.

If the repeatability of single records in these published studies was approximately of the usual size, +.3 to +.4, most of the bias between the

sire indexes calculated on the two groups disappears when the proper correction is made for the effects which selection had in making records and real abilities of dams differ systematically; *i.e.*, for the regression of future records on selected records. However, since the actual repeatability of single records was not measured in the studies cited, it is not clear whether imperfect repeatability is the whole explanation for the daughters differing so much less than half as much as their selected dams did. The investigations reported in the present paper were undertaken to see whether still other circumstances need to be considered when using sire indexes for bulls mated to selected groups of dams.

There were two separate investigations nearly alike in procedure. The first was made by Jay L. Lush and Floyd Arnold and bits of the findings were published briefly in an abstract (7) and a press article (6). The other and more extensive study was made by H. W. Norton, III.[2]

## ANALYSIS OF DATA

### *The First Study*

These data were the 676 daughter-dam comparisons used in proving 103 sires in Iowa Dairy Herd Improvement Associations prior to January 1, 1937. All records were age-corrected, using the Bureau of Dairy Industry factors. Where the bull's mate had only one record the data for her and her daughter were discarded. The mates of each bull were then divided into a high half and a low half, solely on the basis of the *first* record of each cow. All the *later* records of each cow were then averaged into a single figure which was used in all subsequent computations of "later records." Thus each mate had equal weight in the average of later records, whether she had only one or several records after her first. If a bull had an even number of mates with two or more records each, all were used. If he had an odd number of such mates, the one whose first record was median in size was discarded and of course her daughter was discarded with her. This was done so that each sire would have exactly as many daughters and mates in the high group as he did in the low group. Therefore, differences in herd averages or in merit of the various sires could not affect the differences between high and low groups. If a mate had more than one daughter she was used again as many times as she had daughters.

Table 1 shows how the data were arranged for computation. Oakgrove Foxy was mated to eight cows which each had two or more records, but two of these cows had two daughters each, thus making ten daughter-dam comparisons available. The five mates with high first records are placed on the

[2] We are indebted to those in charge of dairy herd improvement association work in Iowa and to the Holstein-Friesian Association of America for making available in convenient form the daughter-dam comparisons on which these investigations were based, and to the American Dairy Cattle Club for assistance in the second study.

TABLE 1

*Sample of data on fat production showing division into "high" and "low" groups*

| Sire which was being proved | High mate's records | | | Daughter's records | | Low mate's records | | | Daughter's records | |
|---|---|---|---|---|---|---|---|---|---|---|
| | First record (X) | Later records | | No. | Average (Z) | First record (X) | Later records | | No. | Average (Z) |
| | | No. | Average (Y) | | | | No. | Average (Y) | | |
| Oakgrove Foxy | 417 | 3 | 436 | 3 | 420 | 270 | 2 | 366 | 3 | 410 |
| | 412 | 1 | 328 | 2 | 461 | 322 | 4 | 401 | 2 | 370 |
| | 372 | 5 | 365 | 2 | 476 | 323 | 3 | 367 | 1 | 442 |
| | 372 | 5 | 365 | 1 | 300 | 281 | 1 | 343 | 1 | 421 |
| | 323 | 2 | 380 | 1 | 330 | 281 | 1 | 343 | 1 | 261 |
| Victory Flash | 453 | 2 | 483 | 2 | 430 | 447 | 2 | 357 | 1 | 394 |
| | 476 | 1 | 494 | 1 | 397 | 326 | 2 | 458 | 1 | 438 |
| | 546 | 1 | 426 | 1 | 382 | 423 | 1 | 333 | 1 | 368 |
| ..... | ..... | ... | ..... | ... | ..... | ..... | ... | ..... | ... | ..... |
| ..... | ..... | ... | ..... | ... | ..... | ..... | ... | ..... | ... | ..... |
| Averages (338 items in each column) | 440.4 | | 407.8 | | 393.4 | 338.3 | | 364.2 | | 379.3 |

Repeatability of differences in single records $= \frac{407.8 - 364.2}{440.4 - 338.3} = .43$

Heritability of differences in single records $= \frac{2(393.4 - 379.3)}{440.4 - 338.3} = .28$

Heritability of permanent differences between cows $= \frac{2(393.4 - 379.3)}{407.8 - 364.2} = .65$

left while the five with the low first records are on the right. The mate's first record (X), the average of all the mate's later records (Y), and the average records of her daughter (Z) are shown in the same line. The rest of the study concerns the average values of X, Y, and Z for the high and for the low groups. Figure 1 shows graphically for both studies the values obtained for X, Y, and Z and the regression of Y and Z toward the average of X.

Table 2 shows the results obtained when the milk yields for the same cows were treated similarly. Naturally the distribution of the cows was not quite identical in tables 1 and 2, since fat percentage varied enough that some cows whose first fat records placed them in the high half for fat had first milk records which placed them in the low half for milk and an equal number whose first fat records were in the low half had first milk records which were in the high half.

The ratio of the Y difference to the X difference, .43 for fat and .48 for milk, shows what fraction of the variance among first records of cows mated to the same bull was due to permanent differences between the cows which made those records. The rest of the variance was caused by temporary environmental forces and circumstances which were different in later lacta-

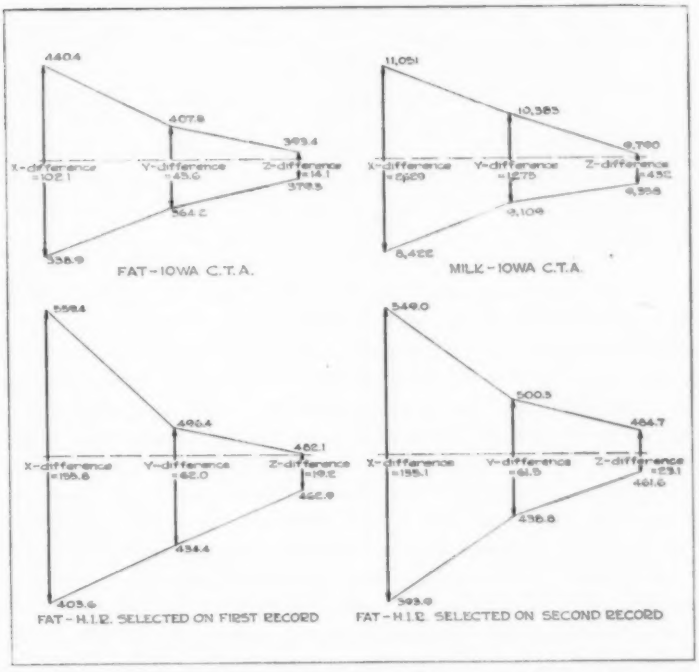


**FIG. 1. Regression of later records and daughter's records from dam's selected record toward the herd average. Each horizontal line marks a level midway between the selected high records and the selected low records. The ratio of the Y-differences to the X-differences is the average repeatability of differences in the selected single records. Twice the Z-differences divided by the X-differences shows the average heritability of differences in the selected single records.**

**That the regression of the future fat records down from the selected high records is slightly greater than the corresponding regression up from the selected low records is interpreted as showing that some of the cows with low first records were culled before they could complete a second record, although the possibility of this being caused by a bias in the age-correction factors is not wholly excluded. That the daughters' fat records averaged below the first records of their dams and just about equal to or a little above the later records of their dams can hardly be blamed on any bias in the age correction factors, but it is in accord with the hypothesis that these dams are the survivors of some distinct selection practiced after their first records were made and that bulls bred to them were on the average just about equal to these cows in breeding value,—a bit better in the H.I.R. data.**

tions. Because temporary circumstances had so much effect on the size of each record the later records (Y) regressed far toward the herd average. The real abilities of the cows differed only 43 (48 for milk) per cent as much as their records did.

TABLE 2

*Average milk yields when data were divided according to size of the mate's first milk record*

| | Low group | High group | Difference |
|---|---|---|---|
| Mate's first record | 8,422 | 11,051 | 2,629 |
| Mate's later records | 9,109 | 10,383 | 1,274 |
| Daughter's records | 9,358 | 9,790 | 432 |
| $\frac{1274}{2629} = .48$ | $\frac{2 \times 432}{2629} = .33$ | $\frac{2 \times 432}{1274} = .68$ | |

In terms of correlation, the ratio of the Y differences to the X differences approximates the intra-herd "repeatability" of single records, *i.e.*, the correlation between single records made by the same cow.[3] This repeatability coefficient describes the average condition within these populations, each of which consisted of cows mated to the same bull in an Iowa D.H.I.A. herd. Lower repeatability would be expected in populations where the cows were more uniform in their real ability or where individual environment varied more widely and irregularly from one lactation to another. Repeatability would be higher in populations within which the cows were more diverse in their real abilities or where intra-herd environmental conditions of all kinds were more rigidly equalized than here. Since each population in this study pertained to only one bull and included only those mates which had at least one tested daughter and two records of their own, and since there is little mixing of breeds in Iowa dairy herds, each such population is probably just a shade more uniform than a truly random sample taken from a whole breed but kept in the same herd would be. Cows leaving the herd before they finished two lactations could not appear here and such cows would include more than a fair share of the lowest producers. The group of cows mated to one bull would in many cases contain two or more which were half or three-quarter sisters by descent from preceding sires.

If the dam's own real ability were identical with her breeding value (which is the same thing as supposing that all differences between permanent abilities are hereditary and that the actual effect of each gene—that is, the phenotypic change produced by substituting it for its allel—is the same in every kind of genotype as it actually averages in that population), then the two groups of daughters by the same sire would tend to average half as far apart as their dams. Actually the daughters do not differ that

[3] Strictly speaking, it is an approximation to the regression instead of the correlation but where the standard deviations of first records and of second or later records are equal, as was approximately true in these data, the regression of future records on single records and the correlation between single records are identical. Estimating a regression by this high-half-versus-low-half method is not quite as efficient at getting out of the data all the information they contain as is the least squares method, but it is not consistently biased in either direction and may at times be simpler to compute and to explain.

much. Half the difference between the Y values is 21.8 pounds of fat and 637 pounds of milk, whereas the actual differences between the Z values are but 14.1 pounds and 432 pounds, or about two-thirds as large as they would be if all differences between the real abilities of the dams were additively genetic.

The other third of the permanent differences in ability can have been due to one or more of three things, quite diverse in principle but not separable from each other in the present data. First, some of the permanent differences between the dams may have been caused by environmental peculiarities which were permanent throughout the lifetime of each dam, or at least extended over more than one lactation. For example, if a cow's udder was damaged permanently by improper feeding, or by any other environmental cause before she made the first record, that would not alter her breeding value but would lower her producing ability in all lactations. Secondly, some of the dams might, on account of dominance, have permanent abilities higher or lower than correspond to their breeding values. If dominance exists, the daughters will on the average regress farther toward the mean of the herd than would be expected if dominance did not exist, regardless of whether it is the genes for high or for low production which are dominant or whether this is mixed, the gene favoring high production being dominant in some pairs and the gene for low production being dominant in others. Thirdly, some of the genes may in certain combinations produce more (or less) than their average effects; *i.e.*, some genes may have their effects made larger in some genotypes and smaller in others because of complementary, inhibitory, or other epistatic interactions with other genes. When the dam transmits a sample half of her genes to her daughter, many of these special combinations will of course be scattered. To the extent that the constituent genes can produce their effects only when all are together in those peculiar combinations, the daughters generally will not deviate as far from the breed average as would be expected from the permanent abilities of their dams.

Since these three diverse causes for a cow's real ability being higher or lower than her breeding value, together account for only about a third of the variance in the real abilities of a bull's mates (only about one-seventh of the variance in single records), and since it seems certain that some of this one-third is caused by permanent differences in environment, it appears that neither dominance nor epistasis (nicking) were highly important in causing the differences which existed among the cows mated to the same bull. Yet one cannot conclude that either of these two was totally absent unless he assumes that *all* discrepancies between permanent ability and breeding value were caused by environmental effects which differed from cow to cow among the mates of each bull but were the same from lactation to lactation for the same cow.

### *The Second Study*

These data came from the first eight volumes of the Holstein-Friesian Herd Improvement Registry Year Book. All sires having at least six daughter-dam comparisons in which the dam had at least two records were used. There were 209 such sires[4] with a total of 3010 daughter-dam comparisons. Only the records of fat production were studied. All records were adjusted to maturity and to three-times-milking per day, using the conversion factors developed for that purpose in the Holstein-Friesian Advanced Registry Office.

The data were analyzed by the same procedure used in the first study. Then the process was repeated, this time dividing the dams into a high and a low half on the basis of their second record rather than their first. The first was then averaged with the third and later records, if any, to get an average of the cow's unselected records. This repetition of the analysis, but with the second record as the independent variable, was done merely to see whether the large regression from selected first records to future records was in any way peculiar to or dependent on the fact that the selected record was *the first* record.

The results are shown numerically in table 3 and graphically in figure 1. The regression of real ability on selected record was almost exactly the same (barely under .4) whether the dams were selected on their first record or on their second.[5]

The difference between the daughters is 3.9 pounds larger when the dams were sorted on their second records than when they were sorted on their first. This difference is probably too small and subject to too much sampling error to deserve much attention but it suggests that a cow's second record may be a shade better indicator of her breeding value than her first record is. Among first records 25 per cent of the variance seems to be hereditary in the narrow sense (additively genetic) while the corresponding figure for second records is 30 per cent. These two estimates are independent of each other, since the independent variables (dam's first record in the one case and dam's second record in the other case) do not include any of the same data. The two estimates agree reasonably well. They indicate (as might have been expected) that the moderately low repeatability and other findings from the first study were not peculiar results of using the first record instead of some later record for sorting the cows into "high" and "low" groups. Sorting on the second record gave almost the same

[4] If any of these were also proved in Iowa Dairy Herd Improvement Associations before 1937 they would have been included in the first study also.

[5] The close similarity of the two results is not surprising, since many of the cows had only two records. Had this been true of them all, the two regressions must have been equal unless the standard deviation of the first records was different from that of the second records. That is, the two figures are by no means independent estimates of the repeatability in these data.

TABLE 3

*Average fat yields in data used for proving sires in Holstein-Friesian Herd Improvement Registry*

| | Low group | High group | Difference |
|---|---|---|---|
| When divided on mate's first record: | | | |
| Mate's first record | 403.6 | 559.4 | 155.8 |
| Mate's later records | 434.4 | 496.4 | 62.0 |
| Daughter's records | 462.9 | 482.1 | 19.2 |
| $\frac{62.0}{155.8}=.40$ | $\frac{2\times 19.2}{155.8}=.25$ | | $\frac{2\times 19.2}{62.0}=.62$ |
| When divided on mate's second record: | | | |
| Mate's second record | 393.9 | 549.0 | 155.1 |
| Mate's other records | 438.8 | 500.3 | 61.5 |
| Daughter's records | 461.6 | 484.7 | 23.1 |
| $\frac{61.5}{155.1}=.40$ | $\frac{2\times 23.1}{155.1}=.30$ | | $\frac{2\times 23.1}{61.5}=.75$ |

results as sorting on the first. Presumably sorting on the third or later records would do the same except as the increasingly stringent selection, entailed by confining the study to cows with three or more records each, might reduce the amount of variance in the real abilities of the population which remained. Permanent but non-transmissible differences between cows are not a large fraction in either case—15 and 10 per cent, respectively, of the variance in single records, or 38 and 25 per cent of the variance in permanent abilities.

### *Comparisons with Other Studies*

In none of the earlier studies in which mates were divided into a high and a low group was the repeatability of single records investigated. Therefore the present studies cannot be compared with them on that point. However, the present figures ranging from just under .40 to .48 do agree well with most studies of intra-herd repeatability in which the data had not extended over a long enough period of time for time trends to be important, or where the cows with early low records had not first been largely culled, as by restricting the study to cows which each had many records.

The earlier studies do permit computing the regression of daughters on dams. The difference between the daughters of the high and the low groups can be doubled and divided by the difference between the records on which the dams were separated into high and low groups. This yields a figure for heritability of differences among those first records, comparable to the 28 per cent for fat and 33 per cent for milk found by Lush and Arnold or to the 25 per cent and 30 per cent found by Norton for fat. Table 4 shows such a summary prepared from the earlier studies known to us. The heritability figures in table 4 are somewhat higher than those we found.

TABLE 4

*Summary of evidence on heritability, earlier studies*

| Author | Characteristic | Difference between high and low groups | | Heritability[a] | Notes |
|---|---|---|---|---|---|
| | | Dams | Daughters | | |
| Gifford | Fat (lbs) | 278.7 | 32.2 | .23 | 21 Holstein-Friesian bulls[b] |
| Gifford | Fat (lbs.) | 240 | 61.6 | .51 | 18 Guernsey bulls[c] |
| Copeland | Fat (lbs.) | 244 | 52 | .43 | 20 Jersey bulls[d] |
| Edwards | Milk (lbs.) | 2856 | 592 | .41 | 23 bulls[e] |
| Rice | Milk (lbs.) | 6373 | 1815 | (.57) | 10 bulls, dairy breeds[f] |
| Rice | Test (%) | 1.09 | 0.47 | (.86) | 10 bulls, dairy breeds[f] |
| "Brain Truster" | Milk (lbs.) | 5025 | 945 | .38 | 1 bull with 151 daughters |

[a] Twice the intra-sire regression of daughters on dams.

[b] A.R. records. Each bull had at least 24 daughter-dam comparisons. The mates of each bull were divided into high, medium, and low thirds (approximately). The figures given here are averages computed from Gifford's table 12, giving equal weight to each sire.

[c] A.R. records. Each bull had at least 17 daughter-dam comparisons. Mates divided approximately in high, medium, and low thirds. The figures here are averages from Gifford's table 1, giving equal weight to each sire.

[d] R. of M. records. Each bull had at least 19 daughter-dam comparisons. Mates were divided approximately into high, medium, and low thirds. The figures quoted are from the summary of Copeland's table 3.

[e] Data from British milk recording societies in East Anglia and Lanarkshire and from agricultural college herds at Reading, St. Albans and St. Paul. Mates divided into high and low halves. The figures quoted are averaged from columns 4 and 5 of Edwards' table 3, giving each cow equal weight. As Edwards used average records where available (up to three lactations per cow), the heritability figure shown here pertains to differences between average records rather than single records. If the intra-herd repeatability of single records in Edwards' material was .4, the heritability of differences in single records would be somewhere between the .41 shown here and the .24 which would be approached if every mate had three records.

[f] Data are official records from several dairy breeds. Each bull had at least 17 daughter-dam comparisons. For each bull the five "highest producing" mates and the five "lowest producing" mates were selected. Division seems to have been primarily on total fat production and was for milk and test only in so far as they were dependent (statistically) on total fat production. This makes the records for the dams' milk and test come much nearer to representing the dams' real ability than if division into high and low groups had been primarily on the milk records and the test records respectively. The figures for heritability therefore are much too high to be fairly comparable with the others and come nearer to indicating the fraction of the differences in real ability (not records) which are due to additively hereditary differences between the cows.

We do not know whether this difference is statistically significant and needs an explanation. One possible reason for such a difference is that their data may have contained more inter-herd differences than ours. Most of the previous studies were confined to bulls which had an unusually large number of tested daughters. Doubtless that increased the proportion of cases where some of the dams and daughters were kept in one herd while others

were kept in another where the management differed.[6] This would have contributed an environmental portion to the daughter-dam correlation. Restricting the study to bulls which had very many daughters would also extend the time over which the daughter-dam comparisons had accumulated and would offer a little more opportunity for time trends in management to contribute to the observed correlation. Another conjecture is that our data, being D.H.I.A. or H.I.R. records, may have included a noticeable fraction of lactations made under circumstances abnormal enough that the owner would not have placed the cow on test if the matter had been left to his choice. That is, it is thinkable that other changeable circumstances do play a larger part—and genuinely hereditary differences consequently a smaller part—in such data as ours than in official test figures such as were investigated in most of the earlier studies. In any event the discrepancies between the figures for heritability in table 4 and those in tables 1, 2, and 3, are small.

## DISCUSSION

### *Repeatability*

By far the most important source of error in estimating the breeding value of cows from their records is the error which comes from conditions or circumstances which change from lactation to lactation for the same cow and make her production sometimes higher and sometimes lower than it will be if she is tested again under what are intended to be the same circumstances. The herdsman, or other person who knows the circumstances well, might be able to make some kind of allowance or correction for how the record has been affected by the unusual circumstances he knows (*e.g.*, difficult calving, a touch of milk fever or mastitis, freshening in fly time, two weeks of indigestion at what should have been the peak of her production, unusually good luck in avoiding a normal share of mishaps, etc.), but most such corrections will be so subjective that they can hardly be used by an impartial agency such as a breed association or D.H.I.A. supervisor. How far an observant herdsman's knowledge would actually go toward always explaining why a cow produced better in one lactation than she did in another is uncertain.

Lifetime averages are especially effective for correcting automatically the errors caused by unrecorded variations in environment. Variance due to circumstances which change at random from one lactation to another should be only half as large in averages of two unselected lactations, only one-third as large in averages of three unselected lactations, and so on, as

[6] Our own figures for repeatability and heritability are not absolutely free from that but must be nearly so since most bulls proven in Iowa D.H.I.A. before 1937 and most bulls proven in the first eight volumes of the Holstein-Friesian H.I.R. would have been proven in one herd only.

in single records. The process of averaging does not remove these errors entirely but, if they are random, it sharply reduces them.

Wherever objective correction factors can be developed for important variations in environment, further accuracy can be gained by correcting the original records for unusually good or bad known circumstances, but there are important practical reasons against correcting records too much, lest they get too far from reality.

Wherever simple and impersonal criteria of distinct abnormality can be devised, something might also be gained by omitting records made under circumstances so abnormal that no correction for them can be made (*e.g.*, abortion), but the circumstances justifying such omission would need to be few, definite, and unmistakable.

### *Heritability*

Differences in single records seem to be somewhere between 20 and 50 per cent hereditary, the figures from our own studies being more nearly 25 to 30 per cent. It would of course be desirable to ascertain this figure more precisely and to know whether it is really different in different kinds of records.

Heritability was obtained by doubling the intra-sire regression of daughter on dam. The intra-sire basis was used in order to minimize the environmental contributions to daughter-dam likeness (since it puts most of the data on an intra-herd basis and restricts them to a period rather short for steady time trends to have had much influence) and to avoid analyzing the mating system. Questions of whether the mating system used was materially different from random mating among those selected to be parents were side-stepped by analyzing only the differences between cows mated to the same bull. The extent to which differences between groups of mates were hereditary was thus left unexplored. Genetic differences between groups of mates might be important in a population of partially inbred lines or in a population in which various herds were being selected toward widely divergent ideals.

Our estimates of heritability are a bit too high if there was any general tendency for the owner to give a daughter better environment than the average of the other daughters in his herd merely because he had given her dam better environment than the average of the other dams. Such a primary correlation between the environments of daughter and of dam would have contributed a non-genetic portion of the likeness between records of daughter and dam. We see no way of testing these data to learn whether such intra-herd environmental correlations between daughter and dam did exist but, in view of the feeding and management practices generally followed, we think that such environmental correlations must have

been unimportantly small, save only in the few cases where a sire was proved on daughters from more than one herd.

The definition of "hereditary" used here has included a small part of the epistatic gene effects, in addition to the purely additive ones. Additive gene effects were wholly included (aside from sampling errors), since each daughter gets a half of her dam's genes (and of course whatever average individual effects those genes have in the array of genotypes and environments present in this population), while doubling the regression tends to cancel the halving effects of Mendelism segregation. But only one-fourth of the two-gene epistatic interactions (*i.e.*, the differences between the effects which two non-allelic genes actually do have when together and the sum of their average effects, each considered singly in this population) which are present in the dam would be transmitted to her daughter, only one-eighth of the interactions peculiar to sets of three genes and not exhibited by any one or any two of those genes alone, only one-sixteenth of the four-gene interactions, etc. Hence the method of analysis used here has included in the 25 to 30 per cent of the variance which was "hereditary" not only the truly additive effects of genes but also about one-half of the effects which depended on the interactions of two genes, one-fourth of the effects of three-gene interactions, one-eighth of the four-gene interactions, etc. That such interactions may exist cannot be denied but in these data they can hardly have been very important, since one-half of the two-gene interactions, three-fourths of the three-gene interactions, seven-eighths of the four-gene interactions, etc., are included with the dominance deviations and the permanent environmental effects, which all together constituted only about 10 to 15 per cent of the variance.

### *Changing the Population Average by Culling Cows*

Something about the rate at which the average production of a breed can be increased by culling low-producing females can be estimated from the fact that the intra-sire regression of daughter's record on dam's selected single record is something of the order of one-eighth to one-sixth in our data—a little higher in some of the other studies cited. The annual turnover in dairy herds is around 25 to 30 per cent of the average number of cows in the herd during the year. At least a third of those removals and possibly more than two-thirds are involuntary, being due to such things as old age, deaths, sterility, sales which would not occur if the cow were known to be well along toward calving, etc. If the voluntary selection which can actually be practiced is equivalent to discarding each year one-eighth of the cows which have the lowest records, the heifer calves sired the next year by the same bulls would average about two to four more pounds of fat per year when they come into production than the heifer calves from the preceding year would average. Seath in a study (10) of Iowa and Kansas D.H.I.A.

herds found that culling was not quite as intense as is assumed here. While a closer approximation is much to be desired, we think that these data and general considerations justify the opinion that the maximum amount of such culling of low producing cows as would be possible in herds generally, would not be enough to raise the average genetic productiveness of a whole breed at a rate as fast as three more pounds with each additional year. How rapidly the composition of a whole dairy population could be changed by the selection of bulls is another story and a much more complicated one.

### *Validity of Sire Indexes*

Estimating the breeding value of a bull as equal to the average of his daughters plus the increase of these daughters over their dams rests on the genetic principle that the genotypes of the offspring tend to be midway between the genotypes (breeding values) of their parents and, in practice, on the inference that the average of the daughters' records equals the average of their genotypes and that the average of the dams' records equals the average of their genotypes under the general environmental conditions which are thought to have prevailed in that herd.[7]

[7] Because the interrelations between test (f), total milk (M), and total fat (F), are multiplicative but the segregation and recombination processes of heredity are additive, sire indexes are not quite identical when computed directly for F and when computed indirectly by multiplying together the indexes obtained separately for f and for M. The variables M, f, and F constitute a closed system in that when the values of any two of them are specified the values of the third is automatically fixed, but this does not of itself show which (if any) of them can be considered as primary or causal to the other or others. Several investigators have maintained that M and f are inherited independently and that F results from their interactions. This would make the indirect computation of indexes for F more nearly correct. Other investigators, notably Gaines, have maintained that the faint negative correlation (not far from $-.2$) generally observed between M and f is large enough to require explanation and is just about the size which would be expected if total energy yield (which is so closely correlated with F as to be almost synonymous, at least on an intra-breed basis) were primary. This would make the direct computation of indexes for F more nearly correct.

Whatever the physiological truth about that may be, the consequence of using whichever is the less accurate method of computing the sire index will be to throw into the epistatic portion some of the variance which would have been truly additive if the more accurate method had been used. The indirectly computed index for F exceeds the directly computed one by 2xy where x is the daughters' average test minus their dams' average test and y is the daughters' average milk yield minus their dams' average milk yield. Thus the indirectly computed index is larger than the directly computed one when x and y are both positive or both negative, but falls below it when x and y are of opposite sign. The actual size of 2xy in D.H.I.A. data was studied in a sample consisting of the first sire on each page in the list of proved sires published in August, 1940, as Miscellaneous Publication 393 of the U.S.D.A. For this group of 205 sires the average value of 2xy was $-1.6$ pounds and its standard deviation was 5.3 pounds. The two most extreme values found were $+18$ and $-27$ but only nine per cent differed from zero by as much as ten pounds and three-fourths of them were less than five pounds away from zero.

In the practical use of the index two sources of error are encountered. The first is the sampling nature of inheritance whereby the genotype of any one offspring may be better or poorer than the average genotype of its parents. Since the mechanism of inheritance makes such sampling errors always random, they are as likely to be plus as minus in each case and this source of error can be made unimportantly small (especially for characteristics affected by many genes) simply by increasing the number of offspring and seeing to it that they are an unselected sample.

The second difficulty is that the genotypes of the offspring and of the dams are unknown and can be estimated only from their records (phenotypes). So far as the differences between the individual's genotype and the individual's record are random, errors from this source also are as likely to be plus as minus in each case and can be made unimportantly small by increasing the number of dams and offspring. But in actual practice many of these discrepancies between genotype and record are not random but are more or less consistently biased in one direction. When these biases are large, only a little accuracy is gained by increasing the number of daughter-dam comparisons beyond three or four. Examples of such biased errors are: (1) that the daughters or mates of one bull are kept under an environment more favorable and another bull's daughters or mates are kept under a less favorable environment than the man interpreting the data thinks; (2) that the daughters or the mates used to prove the bull are a selected group—in which case their records tend to be better than their real abilities; (3) that sometimes only the highest record of each cow is used to represent her—in which case the records are generally better than what the cows will really do in the future (a source of bias which is more extreme for the mates than for the daughters since the former will generally have more records from among which to select a high one); and (4) certain rare (and therefore generally unimportant) genetic situations. such as an extreme change from intense inbreeding to wide outbreeding or the reverse, in which cases the daughters may be expected to show more heterosis or more inbreeding depression than their dams.

If the daughters were unselected their average phenotype can be taken as equal to their average genotype under the general conditions of that herd. The possibilities for error in doing this are: (1) random plus or minus errors caused by individual fluctuations in the environment which

While of course it would be intellectually satisfying and scientifically interesting to know more certainly the relative accuracy of the two methods, yet for the practical purposes of choosing or rejecting one sire as compared with another the differences between the two methods are unimportantly small compared to sampling errors and to the ever-present possibility of incorrectly appraising differences in the general environment which prevailed either for the daughters or for the mates of any of the bulls being compared. The difference between these two ways of computing an index for F is of interest chiefly because it has sometimes been interpreted as challenging the general validity of indexes.

affected the various daughters and which may have made the actual records of some higher and of others lower than would generally be typical of cows with such genotypes, and (2) the general environmental conditions of that herd may have been better or poorer than is realized or than in the herd in which was proved another bull being compared with this one. Errors from the first source can be made unimportantly small merely by increasing the number of daughters. There is no such automatic way to guard against errors from the second source. One can only estimate this from records and observations of the feeding and management prevailing in the herds concerned. Such estimates can hardly be perfectly accurate but they are usually helpful, sometimes very much so.

It is now pretty well understood that for the progeny test to be unbiased the daughters should be an unselected sample—although that was not so generally conceded 20 or 30 years ago when arguments were frequently advanced that even a single high-producing daughter proved that a bull *did have the ability* to transmit that level and therefore he should be judged more by his best daughter than by the average of all—with substantially the same logic as is still sometimes offered in favor of using a cow's best record instead of the average of all her records! Yet it is never known that an actual group of daughters was absolutely unselected. The nearest approach to that is when every daughter born is tested. Even then some bulls might have transmitted more zygotic lethals, resulting in resorptions, abortions, or stillbirths, than other bulls. Often some of the daughters born alive die or are barren or are sold before reaching breeding age and no production record from them can ever be had. Pobably most of these omissions result from accidents or circumstances not related to the heifer's innate producing ability and hence do not tend to bias the average of the sire's progeny, but at least a few of these omissions result from constitutional weaknesses or culling for suspected low production, in part hereditary and having some bearing on the sire's breeding value. In short, natural selection *must* and intentional selection *may* impinge on the group of daughters to such an extent that the statement that the daughters must be unselected expresses an ideal which can be approached more or less closely and is very much worth striving for, but is rarely known to have been attained absolutely.

The mates have been exposed to all this selection and more, too. The more times a cow calves, the more chances she has to appear as a dam in the proving of a sire. For example, if about one-third of all calvings result in heifer calves which are raised and tested in the proving of some sire (probably a rather liberal estimate in view of stillbirths, death losses and barrenness among the one-half—approximately—of the calves which are heifers), only one-third of the cows which are culled before their second calving will appear as dams in daughter-dam comparisons. Of those cows

which calve twice, one-ninth would appear twice and four-ninths once as dams in daughter-dam comparisons, while four-ninths would not appear at all. Of cows which calve three times, one twenty-seventh would appear three times, six twenty-sevenths would appear twice, twelve twenty-sevenths would appear once, and only eight twenty-sevenths would not appear at all in sire proof. Thus the dams in the usual sire proof contain a disproportionately large share of cows which for many lactations escaped death or culling, and a correspondingly small share of those which left the herd early.

If the dams were selected solely on their past records in that herd, then the best estimate of each dam's genotype (G) is:

$$G = A + \frac{nh(D-A)}{1-r+nr}$$

in which:

A = the average of herd in which the dam was tested or, more precisely, the average of the whole group out of which the dams were selected.

n = the number of lactation records for that cow.

D = the average of those n records.

h = the heritability of intra-herd differences on the basis of single lactations (*e.g.*, .28 for fat in these Iowa D.H.I.A. data).

r = the intra-herd repeatability of single lactations (*e.g.*, .43 for fat in these Iowa D.H.I.A. data).

For strictest accuracy the average of the above values for G should be used rather than the dams' actual average in computing the sire index, the formula for which then becomes:

$$\text{Index} = \text{Twice the daughter average} - A - \text{Average } \frac{nh(D-A)}{1-r+nr}$$

Now if the dams were unselected the last term tends toward zero, the plus items and the minus items in that average being about equally numerous and tending to cancel each other and it doesn't matter whether D or A is used, as they are nearly equal. But if the dams were themselves a selected group D will exceed A more often than not and the last term will tend not toward zero but toward some figure determined primarily by the size of D – A and of h but also affected by n and by r. The sum of the last two terms lies between A and $\overline{D}$, being $\frac{nh}{1-r+nr}$ of the way from A toward $\overline{D}$ when n is the same for all dams. Where lifetime averages for the dams are used, n will generally average between 2 and 4. The values obtained for h and r in the present study give values for $\frac{nh}{1-r+nr}$ ranging from .36 to .45 when n is 2 and from .49 to .55 when n is 4. It therefore appears that in general the correct amount to be subtracted from twice the daughter average is not far from half way between A and $\overline{D}$ (perhaps a bit nearer the

former), if the values we found for h are typical. Lower values for h would move the correct figure nearer to A, while higher values would make it nearer to $\overline{D}$.

Whether it would be worth while to correct each cow's records to obtain her most probable breeding value (G) to use in place of D in the sire index would depend upon how much more accurate the index is thereby made and upon the labor (mostly clerical, of course) and other costs of making the correction. Where $\overline{D} - A$ is small (*i.e.*, where the dams were not in fact a highly selected group) there has been, of course, little error introduced by selection of the dams and little is to be gained by any correction for it. Where $\overline{D} - A$ is large the use of $\overline{D}$ in the index, without making any allowance for the regression of dams' probable breeding values toward the herd average, makes the sire's index lower than if he had been tested on unselected dams.[8] This will tend to make a sire's index lower than is fairly comparable with a cow's record but, for comparing one sire with another the existence of $\overline{D} - A$ introduces error only to the extent that $\overline{D} - A$ varies from sire to sire. How much variation is there in the intensity with which the mates of different bulls actually were selected? Seath's study (10) of 147 Iowa and 37 Kansas D.H.I.A. herds showed that those cows which remained in the herds at least one more complete year had averaged in the preceding year 16 and 14 pounds, respectively, more fat than the entire herd. (This would be $\overline{D} - A$ of the preceding formulae, so far as any one year's selection was concerned.) There were statistically significant deviations in culling intensity from herd to herd and yet these deviations were not extreme. For example among the 37 Kansas herds this figure varied only from zero to 33 pounds. We do not think such variations will often be extreme. In actual practice no one intentionally selects for low production. Variations in the intensity with which the mates of a bull have been selected occur only because men vary in the importance which they attach to production records, or in their biological and financial freedom to select. Only on rare occasions, as when someone with sufficient wealth assembles a foundation herd by picking a few high record cows from each of many herds, or at the opposite extreme when a man has permitted buyers to top out his herd and starts with the low record remainder to build his herd again, would variations in intensity of selection of mates be extreme.

Where it is suspected that one sire has been used on mates selected with unusual intensity, that can be verified by comparing the records of those mates with the average of their herd in the same years. That will entail more comparison of each cow's record with the herd average than is yet

[8] The increase of daughters over dams is even more severely biased by this circumstance. This seems to warrant some optimism in interpreting such findings as that nearly thirty thousand daughter-dam comparisons in the germ plasm survey reported in the 1936 Yearbook of the Department of Agriculture showed an average decrease of one pound of fat from the dams' records to the daughters' records.

customary, but perhaps no more than should be done. If such a comparison shows that correction for differences in intensity of selection is needed, the mates' records in each case can be brought nearer to their herd average by the formula for estimating G from D. There would be some complications in determining *exactly* how to compute the age-corrected herd average (A) for the comparable years but these will not prevent an approximation accurate enough for the present purpose. Perhaps we will eventually come to consider all records more on that basis, as has been urged to a limited extent in Scotland (byre average) or in Germany (Stalldurchschnitt). In small herds A will be erratic because of sampling errors. The values of h and r should be known with greater precision and, if they really vary much, their values in different kinds of populations need to be better known. In some cases selection may have been primarily for things other than the dam's records and, if those things were correlated with production, this has the effect of making the fraction $\frac{nh}{1-r+nr}$ nearer to unity (which would completely justify the use of $\overline{D}$ and the omission of A from the index) than it is when selection is entirely on the basis of records.[9]

Because increases in n make the fraction $\frac{nh}{1-r+nr}$ nearer to unity and diminish the size of $D-A$ which can be attained, the use of lifetime averages tends automatically to diminish (although it does not entirely eliminate) the bias which selection of dams introduces into the index computed as if $\overline{D}$ were identical with G.

Most of the discrepancy which selection of dams can introduce into the sire index disappears if the dams' records are properly corrected for incomplete *repeatability* (*i.e.*, even without going so far as to correct for incomplete heritability of permanent differences). For example in the present Holstein H.I.R. data, if a composite index for the high dams and one for the low dams is computed, using for each dam her first record (the one on which she was classified as high or low), we get with the low record dams an index of 522.2 and with the high record dams an index of 404.8, the difference being 117.4 which seems alarmingly large, since the bulls are the same. But if we discard the selected record and use only the future records of the very same cows (thus correcting completely for imperfect repeatability) the index with the low dams is 491.4 and with the high dams is 467.8, the difference being only 23.6 pounds which is a bias, to be sure, but is small compared to sampling errors and other sources of error in actual

[9] It should not be inferred that this hints at a short cut to more rapid improvement in production by selecting for something other than records of actual production. What is gained by increasing the size of $\frac{nh}{1-r+nr}$ will be more than lost by the smaller size of $\overline{D}-A$ which can be achieved if the dams are selected for something correlated with productivity rather than directly for their own records of production.

practice. Moreover, even this small difference was produced only by differences in selection of mates more intense (high half versus low half) than would often if ever be met in practice. That this remaining difference (23.6) does not approach zero is due to the fact that some of the differences between the records on which the selection was based were permanent for the cows concerned but were not transmissible to their daughters—*i.e.*, were due to permanent effects of environment, to dominance or to epistatic gene interactions. When these cows are sorted on the second record, the difference between the indexes on the "high" and the "low" groups is 108.9 when the mates are represented by the record on which they were sorted, but only 15.3 when the same cows are represented by all their other records, thus fully discounting the differences between record and real ability. In the Iowa D.H.I.A. data the differences in the fat index were 73.9 when the mates were represented by their selected records but only 15.4 when the same cows were represented by their other records. The difference in the milk index was 1765 pounds with the selected records but only 410 pounds when the very same cows were represented by their other records. These small remaining differences will disappear, too, if heritability (h) is known well enough that correction for it can be made.

It is pertinent to inquire whether there would be less error if A were used in place of $\overline{D}$ in the ordinary form of the index. This would be a little like the Swiss practice of proving a sire by comparing his daughters with the average of the association in which they were tested rather than with their own dams. This is done there to avoid penalizing a bull whose daughters are grazed at the higher altitudes and to avoid giving an unearned premium to the bull whose daughters are kept mostly on the richer pastures in the lower valleys. There will be less error in using A alone in place of $\overline{D}$ alone whenever the average value of $\frac{nh}{1-r+nr}$ is less than one-half. With n ranging from 2 to 4 and with the magnitudes of h and r which are usually encountered this fraction will generally be not far from one-half, probably a bit lower more often than it is higher. In general the larger n and the more h exceeds half of r, the more the advantage swings from using A toward using $\overline{D}$ if either must be used alone. Incidentally one can partially justify extending the index to include daughters out of untested dams, using the herd average (A) in place of the record of each such untested dam and D for each tested dam. This would remove one moderately important practical limitation on the use of indexes. Naturally it would be a coincidence if this happened to give $\overline{D}$ and A *exactly* the proper weights but the composite figure used would be somewhere between them, as the theoretically correct figure would be. Also of course in practice it would be necessary to be sure that the untested dams were in fact untested and that the records were not merely omitted because that would thereby give the bull a higher

index! Perhaps one wouldn't often know A where the dams were untested?

The most effective procedure for giving a bull a falsely high index through selection of his mates would be as follows: Assemble a group of cows which have only one record and that record an unusually low one in the herd in which it was made. Never test these cows again, or at least never use their subsequent records. Breed the bull to them and test his daughters when (some three or four years after the plan is started) they begin to freshen. Merely to state these requirements is enough to show that it would never be profitable for an unscupulous man deliberately to undertake this with the hope of making a profit on the extra price he would then get for the high index of his "proved" sire (if still alive) some four or five years after the plan was begun! Especially would this not appear attractive since the bull's daughters would probably not themselves be especially profitable since they would be out of dams poorer than average, even though not as poor as their records. Moreover the requirements (becoming more widely adopted) that lifetime averages must be used in proving sires, and that all cows in the herd must be tested, go far toward minimizing even this possibility.

### *The Sire Index Compared with the Daughter Average or the Daughter-Dam Difference*

Space prevents a detailed comparison of the various ways proposed for comparing proven sires with each other, but the source of error which is the main object of this study,—more intense selection of the mates of some sires than of others,—biases the daughter-dam difference most, among the commonly used measures of a sire's worth. Selection of the dams makes the increase of daughter over dams too low by the quantity $(\overline{D}-A)\left(1-\frac{h}{2}\right)$ where the dams have only one record each and no correction for imperfect repeatability or heritability is made. The daughter average is biased in the opposite direction by the quantity $(\overline{D}-A)\frac{h}{2}$ which favors the bull mated to the most highly selected cows. Since the index is simply the sum of the daughter average and the increase of daughters over dams, these two opposite biases partly cancel each other in the index, leaving the net bias equal to $(\overline{D}-A)(1-h)$. For values of h lower than two-thirds this bias will be larger, when expressed in pounds, for the index than for the daughter average. But the standard deviation of indexes will be larger than the standard deviation of daughter averages,[10] ranging from only a

[10] The ratio of the standard deviation of the index to the standard deviation of the daughter average in populations in which each daughter and each dam are represented by one unselected record and the standard deviation of single records of daughters is equal to the standard deviation of single records of dams is:

little larger, in populations where the herd differences are extreme and the number of daughter-dam pairs is very large, to about twice as large in populations where averages differ little from herd to herd. When the bias from differences in the selection of dams is expressed relative to the standard deviation of whatever measure is used for the sire (as it should be for comparing the practical importance of a source of error), this bias would be equally serious in the daughter average and in the index when h is somewhere around .4 to .6. When the dams have more than one record each, the h of these computations would be replaced by $\frac{nh}{1-r+nr}$ which is larger. Therefore the general situation on this point is that the daughter average is usually a little less affected by selection of dams than the index is, especially when h and n are small, but this may be reversed when h is large relative to r, and when the dams have several records each.

The daughter average is most vulnerable and the daughter-dam difference is least vulnerable to errors from wrongly appraising differences in management and general environment from herd to herd, with the index again being intermediate but somewhat nearer to the daughter average.

### *Adjusting a Cow's Record for Imperfect Repeatability or Heritability*

Corrections for imperfect repeatability are not usually made in practice, except when comparing individual cows which do not have the same number of records. For most other purposes one will be using an average of the records of several cows. Correcting for imperfect repeatability would lower some of these toward the herd average but would raise others. If the group of cows was unselected, these plus and minus corrections would tend to

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$$\sqrt{4+\frac{1+(n-1)(v-4u)-4t}{1+(n-1)w}}$$

in which n = number of daughter-dam pairs.

w = correlation between paternal sisters.

u = average correlation between daughter and a mate of her sire, other than her own dam.

v = correlation between cows mated to the same sire.

t = correlation between daughter and her own dam.

All these correlations are computed as if the whole population in which these sires were proven was a single unit (*i.e.*, they are not intra-herd correlations). u and v will be approximately the same size and will be roughly equal to the average correlation between herd mates. They are measures of the amount of herd heterogeneity in the population and in most dairy populations thus far studied are something of the order of +.2 to +.4. w will be larger than v by about $\frac{h}{4}$. t will be larger than v by about $\frac{h}{2}$. Where each cow is represented by several records all four of these correlations would be larger and this ratio would be noticeably smaller when n is very small but would not be changed much when n is large.

cancel each other and, therefore, little would be gained by making them. But where the cows were selected partly because they already had records higher than others in the population from which they were taken, more downward than upward corrections for imperfect repeatability should be made and therefore these will not tend wholly to cancel each other. The formula for making the repeatability correction is that a cow's most probable future ability is $\frac{nr}{1-r+nr}$ times as far from the average of the population as the average of her n completed records is, with r being the repeatability coefficient or correlation between different single records of the same cow in that population. Where r = .4, which is close to the value generally found for intra-herd repeatability, this fraction reduces to $\frac{2n}{2n+3}$, which is an approximation close enough and simple enough for general use.

If it is desired to estimate a cow's breeding value instead of her own ability (that is, to discount not only the temporary environmental differences in records but also differences which are permanent in that cow but not transmissible), the r in the numerator must be replaced by the heritability fraction (h) which, of course, will be somewhat less. Thus in the Iowa D.H.I.A. data the fraction for estimating the real future ability of the cow to produce fat becomes that her real ability probably is $\frac{.43n}{.57+.43n}$ as far from the herd average as the average of her past records is, while her breeding value should be estimated at $\frac{.28n}{.57+.43n}$ as far above or below the average of her contemporaries as her actual records average.

### *Age Corrections*

Incidentally, these data have some bearing on the approximate correctness of the age conversion factors used. In the Iowa D.H.I.A. data the dam's first production record (not always her actual first lactation) averaged 389.4 while the later records averaged 386.0. This slight decrease could be interpreted as an average bias in the age correction factors used but it could also be interpreted (and more logically it seems to us) as the result of selection and subsequent regression toward the herd average. Cows with only one lactation could not appear in these data. If some cows were culled because their first lactation was low and before they could complete a second lactation, that would have made the average of first lactations here a bit higher than the abilities of the cows which made them. Cows culled because of unusually low first records could not be there to show the expected regression upward, while cows with unusually high first records would be kept and would show the corresponding regression downward. If the age corrections were completely unbiased and repeatability of single

records were .4, this decline of 3.4 pounds is the amount which would be expected to result from selection equivalent to discarding before they could complete a second lactation the five per cent of the cows which had completed the very poorest first records. This is just a little less intense than the selection Seath found. The average of later records (386.0) is not biased by selection, since all cows with two or more records could be included, provided only that they had tested daughters. In the Iowa D.H.I.A. data the age-corrected first milk records average 9736 and the later ones 9746. If selection for milk records was practiced, some compensating circumstance conceals the results of it, except that the daughters average only 9574. That might be considered either as evidence of selection among the dams or as indicating that the sires did not average as high in breeding value for milk production as their mates.

In the Holstein-Friesian H.I.R. data the first records average 481.5 and the second records average 471.4. This difference is equal to the amount which would be expected if the age correction factors were correct but in these H.I.R. herds selection between completion of the first lactation and completion of the second lactation had been of an intensity equal to culling seven or eight per cent of the cows with the very lowest first records.

Ward and Campbell in an interesting recent paper (11) interpret their data as showing that age corrections should be made by a regression equation and not by multiplication with a percentage correction factor. However, their method really corrects *both* for *age* and for *incomplete repeatability*, in a single operation. The equation for predicting from her first record (X) what a cow will most probably produce (Y) under a fresh sample of environment when mature is simply:

$$Y = (1-r)A + raX$$

where a is the percentage age-correction factor appropriate for the age when record X was made, A is the mature average of that population, and r is the repeatability of single records. This corresponds to the equation under Ward and Campbell's table III except that their r of .64 is the correlation between first record and the average of the four later ones. This .64 corresponds to a repeatability of not far from .51 between single records.—.4139 is approximately equal to $\frac{4r^2}{1+3r}$, a little more or a little less according to inequalities among the various r's and $\sigma$'s. This .51 is for the population as a whole and therefore (to the extent that these New Zealand herd averages differed from each other either because of environment or genetically) is larger than the intra-herd r's which we have been discussing here. The findings of Ward and Campbell do not conflict with the idea that corrections for age alone should be made by multiplying the actual record by a factor appropriate to that age.

*Variability of Records, Abilities and Breeding Values*

A cow's record, being the result both of her own ability and of the impinging environment, is more variable than either of these constituents. Similarly variation in real ability is greater than variation in breeding value. Quantitatively this is shown in Figure 2, using for illustration the

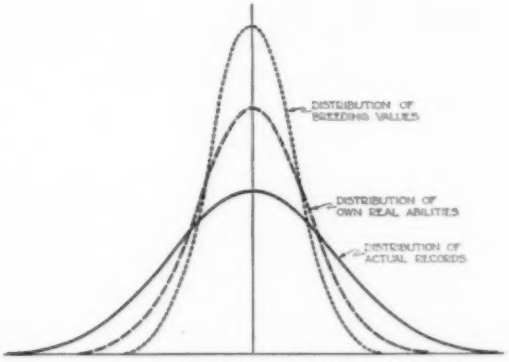


FIG. 2. Normal curves of equal area but with standard deviations in proportion to 100, 66, and 53. While it is not likely that the distributions of records, real abilities, and breeding values are exactly normal (distributions of biological data often being skewed a bit to the right or left for genetic or physiological reasons), yet they are nearly enough normal for this diagram to illustrate with fair accuracy the general principle that breeding values differ less than individual abilities and these in turn (at least for milk and fat production) differ far less than records of actual production. In general the cows with the very best records aren't as good as their records and the cows with the very worst records aren't as poor as their records.

Iowa D.H.I.A. data on fat where the repeatability was .43 and the heritability was .28. The standard deviation of real abilities is $\sqrt{.43} = 66$ per cent as large as the standard deviation of single records. The standard deviation of breeding values is $\sqrt{.28} = 53$ per cent as large as the standard deviation of single records. This leads to the estimate that the intra-herd variation in breeding ability ($\sigma_G$) was about 34 pounds of fat in Iowa D.H.I.A. cows and 49 to 53 pounds in H.I.R. data. About half of the difference between these two standard deviations would be expected to result from the H.I.R. data being corrected to a three-times-per-day milking basis. The rest of the difference may not be significant but it suggests that average H.I.R. management conditions are such as to expand the variation in records to a wider range than under C.T.A. conditions without, however, altering noticeably the proportion of that variation which is due to differences between the cows.

In any event these estimates give grounds for careful scrutiny of cases where a bull is supposed to have raised the production of his daughters over

their dams by more than 50 pounds of fat. Even in the H.I.R. conditions only one bull in 40 would be expected to do as well as that if his mates were average cows of the breed and not one in millions could achieve a real genetic increase of as much as 100 pounds. This is not to cast doubt on the accuracy of the records when such cases are reported, but to call attention to the great probability that the daughters were managed better than their dams, or were a selected sample, or that these dams had records far below their contemporary herd average, or that the number of daughter-dam pairs was not large enough to keep chance from playing a large rôle. The loopholes in sire "proof" are often large.

## SUMMARY

The major source of error in estimating the breeding worth of cows or in interpreting the progeny test of bulls from production records is in environmental circumstances known and unknown which may make one record higher or lower than another, even for the same cow kept for another lactation under what are intended to be the same conditions.

Dominance, epistasis, and individual peculiarities of environment which affect permanently a cow's ability to produce fat are of minor importance in causing differences in the records used to prove sires. All three of these sources of variation combined are only about half as important as permanent differences which are simply transmissible from dam to daughter.

When the mates of a bull were divided into a high half and low half on the basis of one record and then the later records of the mates and the records of their daughters were compared, the sources of variance in single records were found to be as follows:

| Percentage caused by | Iowa D.H.I.A. data (first lactation) | | H.I.R. data Holstein-Friesian | |
|---|---|---|---|---|
| | Fat | Milk | Fat in first lactation | Fat in second lactation |
| Temporary variations in environmental conditions | 57 | 52 | 60 | 60 |
| Permanent but non-transmissible differences between cows | 15 | 15 | 15 | 10 |
| Hereditary differences between the cows | 28 | 33 | 25 | 30 |

Differences in the intensity with which the mates of various sires were selected will bias sire proof, especially the daughter-dam difference and to a lesser extent the index and the daughter average, but this bias is rarely large enough to need much correction in actual practice. Nearly all of that bias can be removed, where necessary, by correcting the mates' records toward the average of the group from which they were selected, so as to

allow for the regression of real ability or transmitting ability on selected record.

The use of lifetime averages automatically corrects for much of the bias which in selected groups exists between the records on which they were selected and their real abilities.

Daughters whose dams were untested can be included in sire indexes, by using the herd average in place of the record of each such dam. Such procedure is more likely to improve than to lower the accuracy of the index, although there is some risk of the latter.

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# DAIRY PRODUCTION MILESTONES

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On June 17, 1938, Dr. H. B. Ellenberger of the University of Vermont presented a paper in the grove next to the dairy building at the Ohio Experiment Station on "The Contribution of Production Research to the Advancement of the Dairy Industry." It seems rather ironical that three years later I should be asked by the General Program Committee to give a paper on the campus of the University of Vermont on "Dairy Production Milestones." Whether or not the Program Committee was justified in this move will be for you to decide later. Whatever your decision may be it remains fitting that we meet in a state where 60 per cent of the agricultural income is derived from milk, and on a campus from which considerable of our dairy knowledge has emanated.

To attempt to go back to the beginning of time and trace step by step the advances that have been made in the dairy production field would be not only too great a task but superfluous. For the purpose of this paper it is not necessary to know that the oldest records of dairying go back to 6000 B.C.; that the Old Testament has many references to cattle, milk, butter and cheese; that all cattle belong to the genus Bos (from which the affectionate term "Bossie" may have originated); nor even that trench silos existed in the days of Caesar. These are matters for classroom discussion—things with which you who teach are more familiar than I. We are more concerned with the dairy production picture as it exists today in this country, the events that have made it what it is, and what the future may hold.

In the beginning, and for some time later, the producer was the whole show in dairying, even after man learned how to make butter and cheese. Until about the middle of the nineteenth century practically all butter and cheese was made on the farm. The first cheese factory was established in 1851 and the first creamery came into existence five years later. From then on the shift was rapid and we find in the official records fifty years later that creameries were making a billion and a quarter pounds of butter a year and that cheese factories were turning out 300,000,000 pounds of cheese annually. What a change had come about!

This shift in labor distribution and responsibility was of great significance to the producer on the farm, for it allowed him more time for improving his cattle and his land. This, plus the coincidental developments occurring during the same period, brought about more changes in the course of

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one century than had occurred in the entire period of history preceding. Among the more important developments assisting in this change were inventions such as the cream separator, the mechanical milker, and refrigeration; discovery of the principles of genetics; the establishment and development of breed associations and other associations designed to spot superior animals and eliminate the boarders; development of feeding standards, nutrition, bacteriology, and chemistry, with the Babcock test the most significant chemical procedure affecting the conduct of the entire industry. We cannot forget either that improvements in agronomic practice contributed much to this rapidly changing dairy world.

The establishment of Federal and State-supported agricultural institutions and a Federal Bureau of Dairying has, of course, made it possible, through the agencies of research, teaching and extension, to discover the facts around which any sound enterprise must be built and to disseminate these, along with other bits of information, to all who would like to know, thus supplementing the original tool of progress—experience.

As a result of the milestones already mentioned and the many more yet to be indicated, where are we today? This can best be answered by comparing the farm dairy enterprise today with what it was 100 years ago, just before the great transition began. There wasn't much to the dairy business 100 years ago. Each farmstead had a few cows that were housed in the winter, when they were usually dry, milked when convenient, and fed whatever happened to be available—grass during the summer, and a little grain, straw, roots, and potatoes during the winter. Later, when corn was common, many cows wintered on corn fodder and a straw stack. The milk was consumed as such by the family or as butter and cheese, except in the case of large herds in the native pasture regions. A good cow in those days was expected to produce about 160 pounds of fat in a year. The highest record known was 12,000 pounds of milk a year. The average yearly production was about 2,000 pounds. Breeding and feeding were haphazard. There was no farm machinery. There were no tower silos. There was no alfalfa; there were no soybeans; there were no commercial fertilizers; there were no commercial feeds; there were no proven sires; there were no county agents, dairy extension men, dairy professors, or dairy specialists. The dairymen were on their own and cattle declined instead of improving until a few wise men like Wintrop Chennery, Phillip Dauncey, and W. G. Duncan imported cattle from abroad, kept them pure, and bred for desirable characteristics.

Today it is different and much more complicated. The dairyman of today must be a smart man to succeed, for he must be an expert in at least four major activities: farm management, production, marketing, and mechanics other than the baling wire type. Given some available labor, capital, land, buildings and fences, machinery, cows, and a few minor sources of cash income such as hogs, chickens, cash crops, or outside work,

the dairy farmer must utilize these resources in such a manner as to realize a profit.

The problems of production are concerned not only with milk but with calves and with crops. For all three of these disease control must be understood. Marketing machinery must be understood in order to make the best disposition of the product. Systems of buying milk must be considered, although we could hardly expect all the dairy farmers of the East North Central States, of which Ohio is one, to know that the "code" price of 100 pounds of milk delivered to evaporating plants is obtained by successively multiplying the monthly average wholesale price of 92 score butter at Chicago by 6, adding 2.4 times the monthly price of "Twins" on the Wisconsin Cheese Exchange, dividing by 7, adding 30 per cent, and multiplying by the butterfat content of the milk. The buying habits of the consumer must be known and sanitary requirements must be observed. For all this many skills are required, not the least of which is the ability to operate and repair farm machinery, without at the same time becoming a machine slave like the farmer, who, when the power failed while running a milking machine, called out the barn door, "Does anyone around here know how to milk a cow?"

Just how involved the dairy production field is can best be illustrated by the curriculum we expect a student majoring in dairy production to follow. At our meeting this year a report will be made on the subject matter that should be covered by a dairy production major. In the field of veterinary medicine alone it will be recommended that he attain quite comprehensive knowledge regarding anatomy, physiology, hygiene and preventive medicine, and pathology. Theoretically he should become fully versed in veterinary medicine as it applies to dairy animals. Multiply this one activity by the many others comprising the dairy production field and you begin to realize how complicated our course of training must be. The importance of physiology in understanding the chemistry and physics of milk secretion, with its intricate hormone relationships, is only too apparent in the literature of recent years, and advancement in both of these fields of endeavor constitutes a momentous milestone.

In spite of the complexities of the business, much progress has been made. In 1940 about twenty-four million cows in the United States averaged 4,575 pounds of milk and 181 pounds of fat. This is almost two and a half times the average of a hundred years ago. But that isn't the whole story, for in 1939 cows in dairy herd improvement associations averaged 7,977 pounds of milk and 323 pounds of fat. Also, we can now boast of a world's record production of 38,606.6 pounds of milk and 1,402 pounds of fat, made by Carnation Ormsby Butter King. This kind of boasting may not be of the right kind, however. We should be more concerned with the long-time production records of groups of cows rather than with unusual

records of scattered individuals. How far we can still go in this direction is indicated by the fact that on January 1, 1941, there were only 763,502 cows on test in 31,381 herds. This represents only slightly over 3 per cent of the cow population.

Further marked improvement activities in the development of the purebred business seems only natural. In addition to satisfying a "hankering" for owning purebred dairy cattle a real impetus seems to be present in the records of purebred herds in dairy herd improvement associations. Last year registered cows in D.H.I.A.'s produced 8,400 pounds of milk and 343 pounds of fat; grades produced 7,728 pounds of milk and 319 pounds of fat. These figures are based on 17,000 and 21,000 random samples of registered and grade records, respectively.

It has been estimated that there are about 175,000 registered sires in service. That's one registered bull for every 138 cows. At one time that would have seemed like an impractical and impossible ratio but with the coming of another milestone, artificial insemination, perhaps it is not. At the present time only one in ten of the purebred bulls born each year is registered. Some of those not registered would not be suitable herd sires but a great many of them are disposed of because there is no market for them. Steps to increase the demand for purebred bulls, together with proper use of artificial insemination, should result in more rapid advancement of the dairy breeds than has ever been possible in the past.

In the economic and agronomic phases of dairy production there have also been many milestones,—too numerous to discuss in detail by one not qualified to do so. The general trend in the economic field has been to reduce costs through more efficient production methods and to facilitate disposition of the product through cooperative effort. About 40 per cent of the milk leaving the farm is now handled by farmer cooperatives at some stage. Interspersed with more economical production procedures have, of course, been new equipment and machinery, new crops, new feeds, new fertilizers and fertilizer treatments, new methods of handling crops, of which ensiling has probably been of greatest importance, and systems of pasturing that have extended the grazing season through greater utilization of early spring and late fall pasture, and by the use of emergency crops to tide over dry periods.

Disease eradication is a field of activity in which the results are only too apparent. We are all familiar with the success of the tuberculosis eradication program. Area testing was completed on November 1, 1940. This meant that in this country bovine tuberculosis had been reduced to less than one-half of one per cent. That is the best record of any country in the world. The history of Bang's disease control is replete with startling discoveries and equally startling but usually ineffective remedies. It was in 1913 that the Vermont Experiment Station qualified for the Blue Book

because it was then that the advocator (Rich) of methylene blue as a remedy for Bang's disease was busily at work at that institution. The test and slaughter program has of course been very effective. Within a period of six years of Federal and State cooperation 346 counties in 20 states were in modified accredited Bang's disease-free areas, and 220 additional counties were under test. That represents progress and every effort must be exerted to see that adequate Federal and State appropriations are made to continue this work. Along with this program there is now the additional procedure of calfhood vaccination which represents another forward step in disease control. The possibility of breeding Bang's disease resistant families is not to be ignored, in view of the progress that has been made in this direction with swine.

Mastitis is now our number 1 disease problem and offers a challenge to research that eventually will be met. We know pretty well how to prevent the spread of this disease from animal to animal, but how successfully to prevent or destroy the infection will be the aim of much talented effort.

The matter of housing was at first one of protection from bad weather. With our increased knowledge of sanitation and physiology many refinements have been made. The relationship between environmental conditions and physiological function is still vague, and perhaps when the facts are all known we will find that we have been pampering too much.

In discussing improvement in milk production it was intimated that proper selection and elimination of animals, as well as intelligent breeding, were responsible. Of course other factors were also at work, the chief one of which probably was improved feeding. Indeed, the phase of dairy production commonly included under feeds and feeding and nutrition affords a series of milestones that are rather well defined and, to one who has been working in this field, these naturally seem especially important. All will at least agree that no matter what inherited ability to produce a cow may have this will not be fully exercised unless she is properly fed.

The first attempt to make dairy cattle feeding something other than haphazard or inconsistent grew out of increased knowledge of agricultural chemistry and resulted in the formulation of feeding standards. Such names as Groven, Wolff, Lehman, Haecker, Kellner, Armsby, Savage, and Morrison are familiar to all students of dairy cattle feeding, for these are the ones who provided the basis for scientific feeding. Protein and energy are the only requirements to be met in a feeding standard and for a long time it was felt that nutritive ratio, an expression of the balance between digestible crude protein, digestible carbohydrates, and digestible fat, was the all-important thing. Balanced rations were the vogue. Now we know that a ration must be not only balanced but complete. Our present feeding standards are probably neither infallible nor final. Even now a new system is

being developed for evaluating feeds, using casein and glucose as reference materials.

Much work has been done on the protein requirement of dairy cattle with the trend being downward with respect to actual amounts needed. Whereas it was once common for grain mixtures to contain 24 per cent or more of total protein it is now common for grain mixtures to contain 12 to 16 per cent total protein and give as good results. This represents an enormous saving, since protein is the expensive ingredient of purchased feeds. The science of nutrition has shown what the end-products of protein digestion are and which of these amino acids are essential for some species. As yet, however, the amino acid requirement of cattle is not known and may be of little importance since the microorganisms of the rumen are capable of converting simple nitrogen compounds into complex proteins. Urea and ammonium salts may some day be important nitrogen sources for dairy cattle.

Digestibility and balance trials, feeding experiments, and net energy determinations have contributed much in rapid succession to our knowledge of dairy cattle nutrition, but no one of these was more important than the now famous Wisconsin experiment in which good results were obtained on a ration made entirely from the corn plant and disastrous results when the wheat plant only was used. The difference between these rations could not be detected by chemical means and suggested that the then current basis of formulating rations was inadequate. This experiment, the results of which were published in 1911, stimulated the use of purified diets with small animals, a procedure which resulted in the discovery of the first vitamin in 1913.

The discovery of vitamins certainly was another milestone in dairy production, although what at first seemed a very complex and critical problem has resolved itself, up to the present, into one of quality in roughages. We now know that dairy animals need the fat-soluble vitamins A and D in their feed, but the simple procedure of furnishing pasture and sunlight in the summer, sun-cured hay of high quality and some kind of silage in the winter, seems to satisfy the body needs for these factors, except possibly in the case of calves born in the fall and winter until such time as they are able to consume two or three pounds of hay.

Of the water-soluble vitamins, those comprising the vitamin B complex offer no problem since it has been demonstrated that thiamin, riboflavin, pantothenic acid, and pyridoxine are synthesized in the rumen. Vitamin C is probably synthesized somewhere within the body and cannot be said to offer a problem in dairy cattle feeding in spite of the beneficial effects on reproduction of vitamin C injections. Within the vitamin field itself demonstration of the remarkable rejuvenating effect of injecting vitamin C into bulls and cows suffering from some form of reproductive failure is one of

the most far-reaching contributions that has been made to economical production.

Vitamin E still affords a field for fruitful research, especially since alpha-tocopherol, the pure substance, is now readily available. Although some European work is quite persuasive as to beneficial effects on reproduction in cattle injected with vitamin E in the form of wheat germ oil, there has been no work on this continent that indicates the need for more vitamin E than is found in natural dairy feeds. This is not proof that additional vitamin E might not be beneficial, and in view of some favorable preliminary work at Iowa with ewes fed wheat germ oil by capsule we must withhold judgment and keep an open mind on this question.

Long before the vitamins were discovered the importance of certain constituents of ash was being demonstrated. Calcium and phosphorus were found to be the principal constituents of bones and their need was readily shown by restricting their intake. Later, their relationship to vitamin D became clear. What milestones they were when the first mineral balances with cattle were run and the actual requirements for calcium, phosphorus and other inorganic substances were determined in many successive experiments. The work with minerals, just as that with vitamins, has taught us the importance of good roughage and has prevented much of the exploitation of individual or "shotgun" mineral and vitamin preparations. At the same time the research has been broad enough to detect the conditions under which additional calcium, phosphorus, iodine, iron, copper and cobalt are needed.

For a long time the fat in feeds was looked upon only as a source of energy, yielding 2¼ times as many calories as the same amount of protein or carbohydrate. With the discovery of the fat-soluble vitamins and of the indispensability of certain fatty acids, the importance of fat assumed greater significance. This was climaxed by the demonstration that fat played some role in milk secretion. Today the amount of fat in dairy feeds is receiving the attention of research workers, farmers, and feed manufacturers.

We have seen many developments in feeds themselves. Processing of all kinds has been tried to improve the original value of feeds: cooking, steaming, enzymatizing, sprouting, chopping, grinding,—just to mention a few. As a rule it has been found that the cow herself is the best processor.

No discussion of the role of feeding in the development of dairy production would be complete without some mention of the commercial feed industry. Many dairy farms could not operate at a profit without having available when needed commercial feed mixtures to supply the nutrients and energy their own farms did not provide, and most dairy farms would not like the prospect of not having readily available a few individual feeds such as wheat bran and one or more of the oil meals. The manufacturers of commercial feeds have much to offer to the farmer and to those who are concerned with his education and improvement. It is gratifying to see the fine rela-

tionship that now exists between (reputable) commercial feed men and those in the educational field, including research. Further improvement of this relationship will prove mutually beneficial.

We now come to a consideration of the material—milk—for the production of which everything that has been said before has some significance. Oliver Wendell Holmes said once that "a pair of substantial mammary glands has the advantage over the two hemispheres of the most learned professor's brain, in the art of compounding a nutritive fluid for infants." That may have been true once but no one can now deny that our present knowledge makes it possible for use to provide the materials from which a better nutritive fluid for infants will be produced. Probably the first clue to this possibility came in 1905 when an investigator in Holland, after finding that the addition of milk to a diet of casein, albumin, rice flour, lard, and a mixture of all the then known essential inorganic salts, made the difference between life and death in mice, wrote "there is a still unknown substance in milk which, even in very small quantities, is of paramount importance to nourishment." Should the writer, Pekelharing by name, be alive today and realize that his unknown substance was really a combination of now recognized vitamins, he would feel much like the piscatorial creature his name simulates.

For a long time the value of milk as a food was taken for granted. Consequently, emphasis was placed on improving the sanitary aspects of milk production. Can't you just picture some of the old town meetings at which some patriarch would get up and say "We're going to have clean milk in this town if we have to take the bull by the horns." As a result of outbursts like this such great advances have been made in the sanitary aspects of milk production that the consumer in communities where milk control is exercised is practically assured of the safety of the milk he drinks.

As the science of nutrition was developed and new hitherto unknown factors that contribute to the value of foods were discovered, the value of milk as a food was reinvestigated. As a result of this newer knowledge of nutrition, many of the things formerly taken for granted have been shown to have sound scientific basis, and other favorable attributes not previously known have been brought to light. At the same time one or two weaknesses or deficiencies were encountered that made it possible better to understand the limitations of milk, as well as its virtues. Knowledge such as this regarding any food product results in more intelligent use of it.

It would be presumptuous for me to attempt to enumerate those factors in milk that make it "the most nearly perfect food," other than to remind you that the concentration of certain vitamins in milk can vary several hundred per cent by employing special conditions such as the feeding of irradiated yeast to increase vitamin D and the use of grass silage for retaining summer vitamin A potency and esthetic appeal.

One approach to an evaluation of the nutritive value of milk as it is produced might be justifiable. There are eleven nutritional factors needed by humans concerning which quite definite information is available. These are calories, protein, calcium, phosphorus, iron, vitamins A and D, ascorbic acid, thiamin, riboflavin, and nicotinic acid. If the required amount of each of these eleven nutrients is considered as 1, and the amount of each nutrient furnished by a quart of milk is given a fractional part of 1, it will be found that 5.5 of the 11.0 units have been supplied.

This does not mean that two quarts of milk will satisfy all the dietary requirements, because at that rate of consumption calories, iron, and certain vitamins would still be short, and there would at the same time be a great excess of other factors, particularly calcium and phosphorus. It does point out strikingly, however, that because of the variety of nutrients furnished, liberal use of milk makes easier the selection of foods that are needed to round out the diet and make it complete.

The comparison just made was based upon milk as it leaves the cow. By the time that milk has been handled, processed, and handled again, some of its original nutritive properties have been lost. More detailed studies of these losses are needed and methods for preventing them must be devised. Otherwise we may some day find ourselves in the same predicament as the millers who after years of milling out some of the most valuable portions of the wheat kernel are now all enthused, with government encouragement, about putting those things back into flour.

That naturally raises the question of mineralization and vitaminization of milk. In a paper given at the Illinois meeting of the American Dairy Science Association in 1933, after justifying the fortification of milk with vitamin D, I made the following statement:

> The general mineralization and vitaminization of foods, including milk, would further complicate an already complicated situation. Vitaminization and mineralization of foods probably cannot be justified except where natural foods fail to furnish these vital factors. This is especially true of milk. To add various vitamins and minerals to milk haphazardly would . . . jeopardize the unique and excellent position which this product now enjoys in the eyes of the general public and the medical profession. In spite of the intriguing mystery and glamor that surround some of the newer discoveries in nutrition we must not lose sight of the fact that plain, ordinary milk is the best single food we have and is thus considered by all. The fact that a sufficient intake of calcium cannot be obtained except by the inclusion in the diet of some form of milk or cheese places these dairy products on a pedestal by themselves.

I still believe that statement, knowing full well that good arguments to the contrary can be advanced.

Let us consider what possibilities there may be. I have here a series of vials, each of which contains a pure vitamin or the purest known form. With our knowledge of chemistry where it is, how simple it would be to add any or all of these to milk without impairing its flavor and possibly improv-

ing its appearance! Should promiscuous fortification of milk be employed the only purpose of feeding cows would be to produce pounds of milk regardless of its food value. Fortunately, however, the present trend of agriculture, plus knowledge gained by experience and research, leans towards systems of feeding that not only produce large quantities of milk but impart to that milk the highest nutritive value.

But why pay any attention to the food value of milk? Do you think for a moment that milk food value education is going to increase milk consumption in a hurry? Not at all, unless a carefully planned, high-class radio program on a national hook-up is used. Education at best is a slow process. If you really want to increase milk consumption reduce the price of milk to the consumer or increase the payrolls. The city of Akron, Ohio, is now at the top of the list with respect to per capita milk consumption. A year ago it wasn't. What happened? For one thing industry has picked up; for another, milk has been sold in gallon jugs for 7, 8, and 9 cents a quart. Take a look at evaporated milk. In 1921 canned milk consumed was 9 per cent of the liquid milk purchased; in 1939, canned milk constituted 13 per cent of the total purchases of milk, *i.e.*, fresh and canned combined. It is quite safe to speculate that even more evaporated milk would be consumed if the flavor were better. I am not advocating jug milk and evaporated milk; I am merely trying to illustrate what price will do.

This becomes more striking when we realize that in normal times nearly two-thirds of our families have incomes of less than $1,500 and that the average income of these families is only $826. Nearly 42 per cent of our families provide only 26 per cent of our food market. That is the explanation of the paradox of want in the midst of plenty. A study of the food purchases of families as related to income shows that the consumption of evaporated milk actually goes down while that of bottled milk goes up as income rises above $750 a year. To what other conclusion can one come than that incomes must be increased or the price of milk reduced if the milk consumption level is to reach the point that seems best for conservation of our greatest natural resource—our people?

If there is a keynote to this address, it is this: economical production and, by inference, economical handling all along the line. I am amused at some of the reports that come to my desk as, for example, the one that listed the estimated price of all milk delivered to a particular market as $2.00 per hundred and the cost of producing that milk, using the Michigan formula, $1.98 a hundred. And yet many of the producers in that milk shed were making money because they were better than average. To raise the average we must have better land, better feed, better cows, and better men. It is our responsibility to help others attain all these things, and that probably means that in the future we will need to work more with the below average man than in the past.

As we meet here this week may we do so in a spirit of thankfulness that our work can be aimed at individual improvement rather than at the welfare of the State or party, for if the world wants to preserve science as a powerful social force for good the research man must be permitted to work without intellectual restraint, *i.e.*, he must be permitted to enjoy the fundamental freedom of democracy.

# THE THIRTY-SIXTH ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

R. B. STOLTZ
*Secretary-Treasurer*

The American Dairy Science Association assembled in the gymnasium on the campus of the University of Vermont in Burlington on Tuesday, June 24, 1941, at 9:30 A.M.

The Honorable Warren R. Austin, Senior U. S. Senator and Trustee of the University, was introduced and delivered the address of welcome.

President Harry W. Cave then gave the following response:

"Senator Austin, I can assure you that we all appreciate very much your kind words of welcome, and the many things which have already been done to make our visit to Vermont pleasant and our meetings a success. Some of us felt that we were coming a long way from home when we came here but the cordial welcome we have received has made us forget that. I only wish that every member of our Association might be here to enjoy your delightful state and the many courtesies being shown us.

"We have come to New England for our thirty-sixth annual meeting because it is a definite policy of the American Dairy Science Association to hold its meetings at various rather widely separated points. In 1939 the annual meeting was held in the far West, then last year in the middle West and now in the East. This plan should make it possible for even somewhat isolated members to attend at rather frequent intervals.

"To further increase the benefits of the Association to its membership, there have been formed three branches of the organization known as the Eastern, the Western and the Southern Divisions. These divisions each hold an annual meeting with a program of contributed papers and a discussion of problems peculiar to the area concerned.

"Last year a committee was appointed from the Southern Division to prepare a history of that organization. This committee, consisting of J. A. Gamble, L. A. Higgins, C. A. Hutton, and J. A. Arey with W. E. Wintermeyer as chairman, presented their report at the annual meeting of that Division held in Atlanta, Georgia, on February 5–7, 1941.

" 'The Southern Division of the American Dairy Science Association had its inception at an informal conference in the hotel room of J. A. Gamble of Maryland during the National Dairy Show which was held at St. Paul, Minnesota, in October, 1921. Those meeting with Professor Gamble to discuss the proposed organization were C. W. Holdaway and F. A. Buchanan of Virginia, L. P. LaMaster of South Carolina, and C. A. Hutton of Tennessee. This group decided to make an effort to establish a Southern

Division and that letters concerning the proposition should be prepared, calling a meeting to be held during the Southern Agricultural Workers Conference scheduled for Atlanta, Georgia, on Feb. 20, 21, 22, 1922. The following letter prepared by J. A. Gamble and C. W. Holdaway was mailed to each dairy worker in the South on February 1, 1922.

Blacksburg, Va.
February 1, 1922

Subject: Meeting of Southern Workers in Dairying at the Association of Southern Agricultural Workers, Atlanta, Ga., February 20, 21, 22, 1922.

Dear Sir:

Arrangements have been completed for the meeting of the workers in dairying in the South for the purpose of forming a Southern Division of the American Dairy Science Association.

Every worker in dairying within the scope of this Division, which should include Maryland and West Virginia on the north, and Kentucky, Tennessee, Arkansas and Texas, and all States south and east of these, should be at the meeting. Every worker is an important factor in the dairy development of our Division and should emphasize his importance by being at this meeting.

The time and place will be on the afternoon of the 21st of February at the Piedmont Hotel.

A few short addresses will be given to emphasize the importance of this organized movement.

If for any reason you cannot be there, mail a letter to me at the Piedmont Hotel enclosing, first, your application for membership in the American Dairy Science Association if you are not a member already, and secondly, your vote on affiliation with the Southern Division when it is formed.

Very truly yours,
(Signed) C. W. Holdaway,
Professor of Dairy Husbandry.

" 'On Feb. 3, 1922, J. A. Gamble, as chairman of the membership committee of the American Dairy Science Association, mailed a letter to the following dairy department heads:

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|---|---|
| H. E. Dvorachek, Arkansas | M. R. Tolstrup, S. Carolina |
| M. P. Jarnagin, Georgia | C. E. Wylie, Tennessee |
| J. J. Hooper, Kentucky | J. A. Clutter, Texas |
| J. M. Cadwallader, Louisiana | C. W. Holdaway, Virginia |
| L. A. Higgins, Mississippi | E. L. Anthony, West Virginia |
| R. H. Ruffner, N. Carolina | |

" 'In this letter Professor Gamble called attention to the Atlanta meeting and enclosed blanks of application for membership in the American Dairy Science Association. A form letter containing information about the Association and an invitation to eligible dairy workers to join was also enclosed.

" 'As announced in the letter sent on Feb. 21 to all workers, the organization meeting of the Southern Division was held on Feb. 21, 1922.

" 'The following are the minutes of that meeting:

The first meeting of the southern members of the American Dairy Science Association was held at 4 P.M., in Room 911, Piedmont Hotel, Atlanta, Ga., Feb. 21, 1922. The members present included:

| | |
|---|---|
| C. W. Holdaway, Virginia | J. A. Gamble, Maryland |
| C. E. Wylie, Tennessee | Stanley Combs, N. Carolina |
| M. P. Jarnagin, Georgia | L. H. Marlatt, Georgia |

In addition to the members of the Association, J. P. LaMaster, South Carolina; J. M. Scott, Florida; R. C. Curtis, North Carolina; Dr. E. S. Good, Kentucky; J. C. Grimes, Alabama; C. E. McWhorter, Georgia, and several other leaders in the dairy and animal husbandry work in the Southern States were present.

The meeting was called to order by C. W. Holdaway of Virginia and J. M. Scott of Gainesville, Fla., was named temporary chairman. C. W. Holdaway was nominated and elected president; C. E. Wylie of Knoxville, Tenn., vice-president; and J. A. Gamble, College Park, Md., secretary-treasurer.

The first business of the meeting was to have the proposal explained and to pass a resolution asking that the executive committee of the American Dairy Science Association grant permission for the formation of a Southern Division of that body. Letters in support of such a proposal were read from several animal and dairy husbandry workers who could not be present.

It was moved that a committee of one be instructed to draft suitable by-laws and present them at the next meeting for discussion and adoption. J. A. Gamble was designated to bring in these suggested by-laws. It was further moved that as soon as the approval for the formation of the Division was received, C. W. Holdaway, the presiding officer, appoint the necessary committees—the committee list of the American Dairy Science Association to be used as a guide in the matter.

All present took part in the discussion relating to the opportunities for service of such a group in the improvement of dairy conditions in the Southern States. It was the general opinion that such an organization would not only result in the coordination of teaching, research, and extension work in the subject, but result in activities such as sectional dairy cattle and dairy products judging contests, to be held once a year at some central point.

The meeting of the group adjourned at 6 P.M.

(signed) J. A. GAMBLE,
Secretary-Treasurer.

" 'A second meeting was held the next morning, Feb. 22, 1922, at which the proposal to sponsor dairy cattle and dairy products judging contests was discussed. A committee was appointed to present the matter to the superintendent of the Southeastern Fair Association and report back.

" 'Arrangements were made for a picture of the newly organized group to be taken on the steps of the Carnegie library at 12:30 P.M. and copies of this picture have been preserved.

TOP ROW—E. L. Jordan, La.; S. Combs, N. C.; McWhorter, Central of Ga. R. R.; Rigdon, Central of Ga. R. R.

SECOND ROW—C. E. Wylie, U. of Tenn.; J. P. LaMaster, Clemson Coll.; J. F. Bazemore, Central of Ga. R. R.; E. S. Good, U. of Ky.; John M. Scott, Fla. Agr. Exp. Sta.

BOTTOM ROW—L. H. Marlatt, U. of Ga.; C. W. Holdaway, Va. Polytech. Inst.; J. A. Gamble, U. of Md.; L. J. Horlacher, U. of Ky.

" 'Under date of Feb. 24, 1922, J. A. Gamble, the newly elected Secretary-Treasurer, wrote President C. H. Eckles of the American Dairy Science Association requesting permission from the Executive Committee to organize a Southern Division of the Society. He enclosed twenty applications for membership.

" 'Favorable action on the part of the executive committee was reported by J. B. Fitch, secretary-treasurer of the Association, in a letter to J. A. Gamble dated March 16, 1922.

" 'The officers of the newly formed division arranged a program of papers and discussions for a regular meeting held Feb. 6 to 8, 1923. It is significant that the first subject under discussion was that of pasture grasses and pasture management for the South, presented by C. E. Piper, Forage Crops Division, U. S. Department of Agriculture. Attention given this

subject by early leaders of the Southern Division has helped to give it much needed impetus in the Southeastern states. Other papers presented at this and later meetings had to do with problems in teaching, feeding, breeding, etc., peculiar to the South. Each year a meeting is held during the annual convention of the Southern Agricultural Workers and the division has continued to grow in size and its activities.

"'The chairmen who have served the Southern Division since C. W. Holdaway in 1923, have been:

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| C. E. Wylie, Tenn. | 1924 | R. B. Becker, Fla. | 1933 |
| J. P. LaMaster, S. C. | 1925 | A. D. Burke, Ala. | 1934 |
| C. A. Hutton, Tenn. | 1926 | R. H. Lush, La. | 1935 |
| J. S. Moore, Miss. | 1927 | E. C. Elting, S. C. | 1936 |
| J. S. Moore, Miss. | 1928 | A. H. Kuhlman, Okla. | 1937 |
| A. C. Baer, Okla. | 1929 | C. N. Shepardson, Tex. | 1938 |
| R. H. Ruffner, N. C. | 1930 | T. B. Harrison, Tenn. | 1939 |
| L. A. Higgins, Miss. | 1931 | C. G. Cushman, S. C. | 1940 |
| Earl Weaver, Okla. | 1932 | R. E. Waters, Miss. | 1941 |

"'The secretaries since J. A. Gamble, who served during the period 1923 to 1926, have been:

| | | | |
|---|---|---|---|
| J. P. LaMaster | 1927 | A. H. Kuhlman | 1935 |
| A. C. Baer | 1928 | C. N. Shepardson | 1936 |
| L. A. Higgins | 1929 | T. B. Harrison | 1937 |
| J. S. Moore | 1930 | C. G. Cushman | 1938 |
| R. B. Becker | 1931 | R. E. Waters | 1939 |
| A. D. Burke | 1932 | C. D. Grinnells, N. C. | 1940 |
| R. H. Lush | 1933 | R. B. Becker | 1941 |
| E. C. Elting | 1934 | | |

"The object of our Association should be to serve dairy workers and the dairy industry as universally as possible. Our field of service has been expanded and our membership greatly strengthened through these branches of the parent organization, the Eastern, the Western, and the Southern Divisions.

"I would not close without expressing my sincere appreciation to the officers, the directors, the many committee members, and the individuals who have assisted in carrying on the work of the Association during the past year. Our organization is steadily growing and its work is constantly becoming more complex. The point has long ago been passed where this work could be done by a few officers. It has been a real pleasure to me to find the great willingness with which the many who were called upon, accepted the duties requested of them.

"We are now facing a future of great uncertainty. Our Association and our membership may be called upon for much greater contributions in the near future than in the past. With such hearty cooperation as has been

shown by our members in the past I have little fear but that they will give a good account of themselves whatever may come in the future."

President Cave then introduced Dr. W. E. Krauss, Associate in Dairy Nutrition Ohio Agricultural Experiment Station of Wooster, Ohio, who gave an address entitled, "Dairy Production Milestones," which will be found printed elsewhere in this issue of the Journal.

There were 298 members present. The meeting adjourned at 11:30.

## GENERAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

*Burlington, Vermont, June 26, 1941*

President Cave called the meeting to order at 3:30 P.M. in the Fleming Museum, there being 124 present. Mr. Charles Blackman, chairman of the Necrology Committee, reported the death of the following members during the past year: Edward B. Meigs, A. R. Schubert, Elmer S. Hinman, Hugo Larsen, Clarence H. Redding, and Godfrey L. A. Ruehle. Information regarding the activities of these deceased members was contained in the report of the committee. Upon motion duly seconded the report was accepted to be made a matter of record in the minutes.

Editor Sutton then gave a report which will be found in the minutes of the board of directors.

### MANUFACTURING SECTION

Secretary Anderson of the Manufacturing Section presented the following report:

The manufacturing section held its meetings at the scheduled hours and places. Mr. C. D. Dahle, chairman, presided.

All papers were presented as announced with the exception of "Production of Cream on Farms and in Plants," M 9, M 17, and M 30.

The business of the section was transacted at three meetings held at the announced places.

Reports were submitted by the various standing committees:

1. Committee on Chemical Methods for the Analysis of Milk and Dairy Products, L. C. THOMSON, *chairman*. The written report was accepted.

It was voted to appoint a special committee to compare the accuracy of the Gerber test with the Babcock test for milk and milk products.

It was voted that the chairman of the committee on the Chemical Analysis of Milk and Dairy Products act as coordinator in coordinating the work of said committee with like committees of other associations doing similar work. The report was accepted.

H. F. JUDKINS—PRESIDENT ELECT

2. Committee on Quality of Milk and Milk Products. W. V. PRICE in the absence of W. H. E. REID, *chairman*, called for sub-committee reports.

a. Cream quality—P. A. DOWNS, *chairman;* written report accepted.

b. Cream and butter quality—W. H. BROWN, *chairman;* written report accepted.

c. Ice cream—no report.

d. Cheese quality—W. V. PRICE, *chairman;* written report accepted.

e. Market milk—F. C. BUTTON reported for P. H. TRACY, *chairman;* written report accepted.

f. Condensed and milk powder—E. H. PARFITT, *chairman;* oral report accepted.

3. Committee on Students' National Contest in Judging of Dairy Products. G. M. TROUT, *chairman;* written report accepted.

4. Committee on Methods of Determining the Curd Tension of Milk. F. J. DOAN, *chairman;* written report accepted.

It was voted to accept the procedure for determining the curd tension of milk as recommended by the committee and that the committee be discharged.

5. Committee on Score Cards. C. J. BABCOCK, *chairman;* written report accepted.

It was voted to delete the flavor items under "remarks" on page 3 of the report and substitute words "flavor defects" listed on the other side.

It was voted that the score card for milk be approved as amended by the Manufacturing Section and submitted to the parent organization for final approval.

It was voted that the score card for ice cream be approved by the Manufacturing Section and submitted to the parent organization for final approval.

It was voted to accept the recommendations of the committee that cream be scored the same as milk until such time as a satisfactory score card can be devised.

It was voted that the committee remain active until it completes a score card for cream.

6. Committee To Study Methods for Measuring the Oxidation of Milk Fat. O. F. GARRETT, *chairman;* written report accepted.

7. Committee on Methods of Measuring the Color of Milk. O. F. GARRETT, *chairman;* written report accepted.

8. Committee to Study the Ways of Improving Summer Meetings of the Manufacturing Section. B. E. HORRALL, *chairman;* written report accepted. It was voted that the report of the committee be accepted and that the committee be discharged.

It was suggested that the retiring manufacturing chairman carry over as a fourth member of the program committee.

It was voted to appoint a committee of three to work with the present chairman of the section to organize the present complex committee slate, to be effective October 1, 1941.

The following officers of the Manufacturing Section were unanimously elected:

*Vice-Chairman*—R. WHITAKER
*Secretary*—KENNETH G. WECKEL

Mr. L. H. Burgwald, present vice-chairman, automatically becomes chairman of the Manufacturing Section.

Respectfully submitted,

(Signed) E. O. ANDERSON
*Secretary, Manufacturing Section*

Upon motion duly seconded the report of the Manufacturing Section was accepted and ordered to be printed in the minutes. Copies of the written reports of the various committees of the Manufacturing Section were filed with the Secretary for their preservation.

## EXTENSION SECTION

Mr. J. F. Kendrick, Secretary of the Extension Section presented the following report:

In session at the University of Vermont, Burlington, Vermont, June 24th, 25th, and 26th, 1941.

The annual meeting of the Extension Section was called to order by the chairman, Otto J. Hill, June 24 at 1:30 P.M. in Morril Hall. Forty-six members and 25 guests were present from a total of 25 different states.

During the three-day session the various committees of the Extension Section presented their reports supplemented with selected papers on pertinent phases of the dairy extension program.

The Sire Committee's report was presented by the committee chairman, E. J. Perry. The committee approved new age-conversion factor for use in Dairy Herd Improvement Associations; approved the use of Dairy Herd Improvement Association records in selective registry and Star Bull programs of the American Jersey Cattle Club; and recommended uniform methods of compiling annual reports of artificial breeding associations; also approved a bull leasing plan to combat the "stock-yard" bull problem.

Report was accepted.

The Feeding Committee report was presented by Mr. V. L. Gregg. This committee re-emphasized the importance of roughage feeding and outlined a tentative program to be followed by the Feeding Committee in succeeding years. The report was accepted as a progress report.

Quality Committee report presented by Mr. Evert Wallenfelt. The committee outline objectives of quality work to be discussed in future years. Report accepted as a progress report.

The Herd Health Committee reported to the joint session of the Extension and Production Section by Mr. C. G. Bradt. Report accepted as a progress report.

Report of the Joint Committee on Feeding Standards accepted.

Testing Committee report presented by Mr. C. R. Gearhart. The committee reported on standards for supervision of dairy herd-improvement association testing and recommended that further study be given the subject. The report was accepted as a progress report.

Type Classification Committee report given by Mr. J. W. Linn. The committee recommended type classification in herds where all cows are under test. Report accepted.

Exhibit Committee report presented by Mr. C. J. Fawcett. Exhibits illustrating extension methods used in 16 different States were presented.

Resolutions Committee report given by Mr. A. I. Mann, chairman of the Committee. The report was accepted and turned over to the General Resolutions Committee.

During the business session of the Section, Mr. E. C. Scheidenhelm of Michigan was elected Secretary. The officers who will assume their responsibilities on October 1, 1941, are as follows:

GLEN W. VERGERONT, *Chairman*
J. F. KENDRICK, *Vice-Chairman*, and
*Chairman of the 1941 Program Committee*
E. C. SCHEIDENHELM, *Secretary*

Respectfully submitted,

(Signed) J. F. KENDRICK
*Secretary, Extension Section*

Upon motion duly seconded the report was accepted and ordered to be printed in the minutes.

## PRODUCTION SECTION

The Production Section held five regular scheduled sessions. Of these, two were symposia combined with the Extension Section and the Manufacturing Section respectively; a third was a Section symposium. The remaining two were devoted to regular papers and discussions grouped as to special subject matter. In accordance with the recommendation of the General Program Committee, this Section this year tested the plan of dividing the group into two divisions, with programs running concurrently. W. E. Petersen, Section Chairman, presided at sessions of Division A; H. A. Herman, Section Vice-Chairman, presided at sessions of Division B.

All sessions were well attended. Thirty-nine of the forty papers scheduled were presented.

The Section held three business meetings. Chairman W. E. Petersen presided at each meeting.

The minutes of the 1940 Annual Meeting of the Production Section at Lafayette, Indiana, were read and approved.

Reports of the various standing committees were submitted and ap-

proved. Copies of these reports are attached. Salient points incorporated in these reports and presented herewith to the General Session for approval are:

1. Breeds Relations Committee. W. T. CRANDALL (New York), *chairman.*

The revision of Rule 7 concerning the supervision of official tests will read: "Where the cows are milked by hand, only one cow may be milked at a time, if in a box stall or individual quarters. Two, however, may be milked at the same time, if milked by machine, or if standing in the stanchions in close proximity and in full view of the supervisor."

2. Committee on Measuring Results of Pasture Investigations. G. BOHSTEDT (Wisconsin), *chairman.*

This committee has continued its efforts of reconciling the viewpoints of workers engaged in pasture research. It is at present concerned with ways and means for printing their latest compilation of methods of pasture investigation technique.

3. Committee on Standard Methods of Analyses. W. E. PETERSEN (Minnesota), *chairman.*

Dr. Petersen stated that due to the large amount of material accumulated by the committee in the various phases of its study, it was deemed impractical to present the combined recommendations in a single report. The committee recommended that in view of the fact that methods of analyses by virtue of constant research were subject to frequent revisions and since the various fields had been carefully canvassed to date, it be discharged as a standing committee. It is further recommended that occasional papers be prepared for publication as reviews in the JOURNAL OF DAIRY SCIENCE, on standard methods of analyses in individual areas of dairy production research.

4. Committee on Rules for Conduct of the Students' National Dairy Cattle Judging Contest. I. W. RUPEL (Wisconsin), *chairman.*

5. Committee on Awards for Students' National Contest in Judging Dairy Cattle. A. A. BORLAND (Pennsylvania), *chairman.*

In addition to the regular awards that have been made at recent contests and that were repeated at the 1940 contest, two scholarships were secured. The Holstein scholarship of $500.00 was provided by Mr. Forry Laucks, owner of Lauxmont Farms, Wrightsville, Pa. The Ayrshire scholarship of $525.00 was provided by a group of prominent Ayrshire breeders in Pennsylvania.

6. The Feeds Specifications Committee. E. S. SAVAGE (New York), *chairman.*

1—The American Dairy Science Association shall prepare through its Feeds Specifications Committee, an official table of analyses of feeds for dairy cattle. This table shall contain the usual percentages of water, min-

eral matter, protein and total digestible nutrients. A column showing the therms of net energy shall be given. The digestion coefficients shall be given as determined by cattle whenever possible. Whatever is available as to mineral and vitamin content shall be given.

2—This table shall be revised annually as new values appear.

3—Referees for different feeds shall be invited by the feeds specifications committee to study and report on single feeds or groups of feeds. These referees shall report annually on changes in analyses and new discoveries with respect to other qualities. Referees shall automatically become ex-officio members of the feeds specifications committee.

4—Efforts shall be made to refine feeding values of feeds by stimulating feeding experiments.

5—The members of the Feeds Specifications Committee shall cooperate fully with feed control officials and with similar committees of the American Society of Animal Production.

A change in the method of the appointment of committees was voted, whereby the incoming Section Chairman was delegated to make such appointments for the ensuing year. It was voted also that all new officers take office immediately following the close of the present annual meeting of the Association. It was felt that such a practice would enhance the formulating of the program for the following year's meeting.

By audible expression and show of hands, the Production Section went on record in hearty recommendation of the plan of program for the present meeting and recommended the continuation of such type of program.

Several excellent suggestions were made for symposia topics for future meetings.

Professor J. C. Knott, chairman of the nominating committee, presented names of candidates for offices of vice-chairman and secretary of the Section for 1941–42. K. L. Turk, Maryland, was elected vice-chairman; and Dwight Espe, Iowa, was elected secretary. H. A. Herman, Missouri, vice-chairman for 1940–41, automatically becomes chairman.

Respectfully submitted,

(Signed) K. S. Morrow
*Secretary, Production Section*

The following list of committees for the Production Section for 1941–42 was named by Section Chairman H. A. Herman and submitted to the secretary following the reading of the foregoing report:

1. *Breeds Relations Committee:*

F. W. Atkeson, Kansas, *Chairman* (1 year)
H. A. Herman, Missouri, *Secretary* (2 years)
Floyd Johnston, Iowa (1 year)
W. W. Yapp, Illinois (2 years)

J. B. FITCH, Minnesota (3 years)
E. C. SCHIEDENHELM, Michigan (3 years)

2. *Committee on Measuring Results of Pasture Investigations:*
   G. BOHSTEDT, Wisconsin, *Chairman*
   R. H. LUSH, District of Columbia
   I. R. JONES, Oregon
   R. E. HODGSON, Washington
   C. B. BENDER, New Jersey
   R. B. BECKER, Florida

3. *Committee of Standard Methods of Analyses:*
   Committee excused.

4. *Committee on Rules for Conduct of Students' National Dairy Cattle Judging Contest:*
   I. W. RUPEL, Wisconsin, *Chairman*
   S. M. SALISBURY, Ohio
   J. R. DICE, North Dakota
   E. M. HANSON, Iowa
   P. M. REAVES, Virginia

5. *Committee on Awards for Students' National Contest in Judging Dairy Cattle:*
   A. A. BORLAND, Pennsylvania, *Chairman*
   BURT ODERKIRK, Babson Co., Illinois
   G. E. TAYLOR, New Jersey
   I. W. RUPEL, Wisconsin

6. *The Feeds Specifications Committee:*
   (From the Production Section)
   E. S. SAVAGE, New York, *Chairman* (2 years)
   G. BOHSTEDT, Wisconsin ( 1 year)
   C. D. GRINNELLS, North Carolina ( 3 years)

   (From the Extension Section)
   C. L. BLACKMAN, Ohio (2 years)
   W. T. CRANDALL, New York (1 year)
   M. J. REGAN, Missouri (3 years)

   (Sub-committee on Digestion Coefficients)
   F. B. MORRISON, Cornell, *Chairman*
   W. E. KRAUSS, Ohio
   S. BRODY, Missouri

7. *Committee on Silage Methods, Evaluation, etc.:*

C. B. BENDER, New Jersey, *Chairman*
T. E. WOODWARD (U.S.D.A.)
J. G. ARCHIBALD, Massachusetts
G. BOHSTEDT, Wisconsin
C. F. MONROE, Ohio
J. C. KNOTT, Washington State College

Upon motion duly seconded the report was accepted.

Mr. J. M. Frayer, Chairman of the Registration Committee, reported the attendance of 844 men, women, and children. Of the 492 men registered, 325 were active members and 167, non-members. These members represented 40 of the United States and Canada and the Philippines.

## RESOLUTIONS COMMITTEE REPORT

Mr. K. S. Morrow, Chairman of the Resolution Committee, presented the following report:

The American Dairy Science Association assembled in its 36th Annual Meeting at the University of Vermont, wishes to express for the membership, their families and guests, its appreciation for the hospitality, delightful entertainment and splendid facilities provided by the officials and faculty of that University.

Therefore, be it *Resolved:* That the membership of the Association publicly express its most sincere appreciation to Dean and Director J. L. Hills; to Professor H. B. Ellenberger and his departmental staff; to the Ayrshire Breeders' Association, The American Guernsey Cattle Club, The Holstein-Friesian Association of America, and the American Jersey Cattle Club; to the several Vermont Maple Sugar producers and marketing organizations; and to all other agencies cooperating in the providing of entertainment and the many fine courtesies.

WHEREAS: The general health and physical well being of our people constitute the first essential in our national defense, and,

WHEREAS: The Selective Service Administration is finding an alarming proportion of our young men to be unfit for military service by reason of nutritional defects, and,

WHEREAS: Local, State and Federal health officials have long recognized the importance of an increased consumption of dairy products as a means of promoting national health and have encouraged and assisted the dairy industry in developing programs for the encouragement of increased dairy products consumption, and,

WHEREAS: There is an enormous potential supply of milk which can be developed whenever price and demand are sufficient to justify more liberal feeding of our dairy herds, and,

WHEREAS: The Government can always buy on the open market any needed supplies for shipment to Great Britain, and with this increased demand, effect an automatic adjustment of domestic supply and demand through resultant price changes without discouraging the desire for dairy products.

Therefore, be it *Resolved:* That this Association express its disapproval of any National program specifically designed to discourage the home consumption of dairy products or to develop in the minds of the consuming public the idea that dairy products are non-essential or unimportant in the National diet, which idea is in direct conflict with the long established and generally recognized recommendation of all public health and nutritional authorities, and,

Be it further *Resolved:* That a copy of this resolution be forwarded to the Honorable Secretary of Agriculture for his information.

WHEREAS: There has been a most valuable contribution to the National economy of this country through the educational and research activities of our Federal government, colleges and universities, and,

WHEREAS: The future welfare of the nation will depend to an even greater extent on activities of these agencies, and,

WHEREAS: The present emergency is necessitating the closest scrutiny and most conservative use of public funds and resources.

Therefore, be it *Resolved:* That this Association urge upon all public officials charged with the distribution of public funds, the importance of the continuance of an advancement of this program, and,

Be it further *Resolved:* That copies of this resolution be forwarded to the Honorable Secretary of Agriculture and all State Directors of Experiment Stations for their information.

WHEREAS: This American Dairy Science Association recognizes the valuable contributions made by the pioneer workers in doing research.

Therefore, be it *Resolved:* That this Association give public recognition to the excellent work developed by Dean J. L. Hills in the problem of experimental research methods and for his many other contributions to the field of Agriculture through his long years of valuable service as an instructor and Dean of Agriculture at the University of Vermont.

WHEREAS: The problems of herd health can best be attacked with the assistance and cooperation of all agencies and organizations concerned,

Therefore, be it *Resolved:* That a Herd Health Committee be appointed by the President of this Association to seek the cooperation of the American Veterinary Medical Association and the United States Live Stock Sanitary Board in formulating organized plans for an action program on these problems.

WHEREAS: This Association recognizes the importance of awards in giv-

ing incentive to students throughout the country for continued activity and study in the field of dairy cattle breeding and production,

Therefore, be it *Resolved:* That donors of prizes for the winners in the National Collegiate Students' Dairy Cattle Judging Contest be thanked individually in the name of the Production Section of the American Dairy Science Association by the Chairman of the Committee on Awards.

Be it *Resolved:* That the Dairy Cattle Breed Associations be commended for their constructive action in the organization of the Pure Bred Dairy Cattle Association of America, through which greater unification of plans and methods for the improvement of the various breeds may be attained.

WHEREAS: The Borden Company is continuing its awards for recognition of superior research in dairying.

Therefore, be it *Resolved:* That the American Dairy Science Association express its appreciation to the Borden Company for its continuing interest in dairying.

Respectfully submitted,
K. S. MORROW, *Chairman*
C. Y. CANNON
HAROLD MACY
E. C. SCHEIDENHELM
C. N. SHEPARDSON

Upon motion duly seconded the report was accepted.

### NOMINATING COMMITTEE

Mr. Earl Weaver, Chairman of the Nominating Committee, submitted the following report:

For *Vice-President:* H. P. DAVIS; JAMES W. LINN
For *Director* to succeed M. E. Parker: L. S. PALMER; G. M. TROUT
For *Director* to succeed J. W. Linn: J. C. KNOTT; L. P. LAMASTER

Committee:
EARL WEAVER, *Chairman*
R. B. BECKER
R. R. GRAVES
J. B. FITCH
D. R. THEOPHILUS

Upon motion duly seconded the report was accepted.

### SECRETARY–TREASURER'S REPORT

The Secretary-Treasurer then gave the following report:

The policy of the American Dairy Science Association in conducting their business has been changed in recent years, and at present the Board of Directors, who are elected for a period of three years by ballot, conduct

the business of your Association. It is their wish, however, that a summary of their action be presented to the membership so that the members present at this annual meeting may know as early as possible the action that has been taken by the Board of Directors.

A copy of the Certified Public Accountant's Audit was made February 1, 1941, and mailed to each member of the Board of Directors.

Although you may not be interested in a detailed report, you will be interested in learning that our income last year was $17,347.00 and our operating expenses were $16,542.00. Our net worth is $18,919.55.

Our increased expenditures are largely due to increased cost of our Journal. Up until 1933 our Journals were limited to 550 pages per volume. In 1932 the style was changed so that each page contained an equivalent of one and one-third pages. In 1937 the volume of the Journal contained over 1100 pages which was twice as many pages as the volumes which had been published previous to 1934. Last year our Journal contained 1662 pages or more than three times the previous limit. When one takes into account both the style change and increased number of pages, the XXIII Volume (1940) contained four times as many words as did the volumes previous to 1932.

Our circulation reached 2438 in 1939 and 2406 in 1940, but on June 17 of this year we had 129 greater circulation than at the same time last year which would indicate that our circulation will exceed 2500 this year. This is 50 per cent higher circulation than in 1936 when it was 1652.

Our increased circulation this year is largely due to an increased number of student affiliates. Last year we had a total of 282. At this same date last year we had 242. We now have 368 which is an increase of 126 over last year. Of the 368 student affiliates, Iowa leads with 62. Ohio is second with 43; Wisconsin third with 26; Massachusetts fourth with 22; Illinois fifth with 17. Other states with ten or more student affiliates are Texas, Vermont, Pennsylvania, Indiana, Michigan, Missouri, New York, South Carolina, Virginia and the State of Washington.

### *New Members*

We may expect to lose about 7 per cent of our membership each year by death, resignations or one thing or another. It is therefore essential that each state have new members to the extent of about 7 per cent of their membership to prevent a decreased number of members.

Up to this date this year we have 83 new members; 31 of whom were student affiliates and 52 of whom have paid the $5.00 affiliation fee. Illinois and Pennsylvania lead with 7 new paid members each; Oklahoma, Vermont, and New York tie for third place with 4 each; and Massachusetts, Ohio, and Wisconsin tie for sixth place with 3 each.

Permit me to say a word about the affiliation fee. Some of our members

may not see the need of charging this fee. Our net worth, most of which is invested in United States Government Securities, amounts to $18,919.55. If our 1400 members were to share this equally, each one of us would receive $13.51. It is therefore only proper that these new members who have not contributed anything to this accumulation should pay $5.00 or less than one-half of a membership's value into this fund.

This does not apply to student affiliates. They not only are permitted to receive the Journal at $3.00 per year, which is less than our cost of printing the Journal, but upon finishing school, they are eligible to become full members by merely paying their $5.00 dues. In 1939 we had 156 student affiliates; in 1940, 282; and this year we have 368 student affiliates.

### *Back Copies*

The Association is now prepared to furnish to any of its members or any library a complete file of all back numbers and volumes. We suggest that you check your library and complete your volumes of the JOURNAL OF DAIRY SCIENCE. As soon as the twenty-year index is published the first twenty volumes will be a very valuable reference for your office and library. You will find the price list for back copies printed in the advertising section of the Journal.

### *Advertisers*

We are grateful for the commercial companies that use our Journal as an advertising medium. Last year income for advertising amounted to over $4,000, which is equivalent to the dues of 800 members. Any courtesies shown these advertisers will be appreciated.

### *Reprints*

We recommend that those of you who are in charge of having bulletins printed that you investigate purchasing reprints through our Printers of all articles published in the JOURNAL OF DAIRY SCIENCE. We are of the opinion that the reprints will be furnished you at a lower cost than you will be able to have them printed, and the Association gets a small income from all reprints sold.

The Secretary then reported on all the action taken by the Board of Directors. Motion was made, duly seconded and passed that the Minutes of the Board of Directors be accepted and the Association approve and endorse all action that the Board of Directors had taken during the past year.

# MEETING OF BOARD OF DIRECTORS AMERICAN DAIRY SCIENCE ASSOCIATION

R. B. STOLTZ, *Secretary-Treasurer*

*Burlington, Vermont, 9:30 A.M., June 23, 1941*

A meeting of the Board of Directors of the American Dairy Science Association was held in the Delta Delta Delta House, Monday, June 23, 1941, at 9:30 A.M.

Present: President H. W. Cave; Vice-President H. F. Judkins; Secretary-Treasurer R. B. Stoltz; Directors, J. W. Linn, M. E. Parker, C. N. Shepardson, Fordyce Ely, H. B. Ellenberger, A. C. Dahlberg, E. S. Guthrie.

Editor T. S. Sutton then presented the following report:

## EDITOR'S REPORT

The Editor begs to submit the following brief report to the Board of Directors of the Association:

1. *Summary of Journal Contents.*

A summary of the Journal contents over the past three years is presented in the accompanying table.

SUMMARY OF JOURNAL CONTENTS

| | *1938–39* | *1939–40* | *1940–41* |
|---|---|---|---|
| Number of original articles | 88 | 94 | 97 |
| Pages of original articles | 760 | 826 | 892 |
| Number of reviews | 2 | 3 | 5 |
| Pages of reviews | 26 | 119 | 144 |
| *Miscellaneous* | 140 | 98 | 157 |
| Students National Contest, Proceedings Annual Meeting, Announcements, Circulation, Index, Committee reports. | | | |
| Pages of Abstracts | 232 | 206 | 304 |
| Total number of pages printed | 1158 | 1245 | 1497 |
| *Classification of Articles* | | | |
| Manufacturing articles | 52 | 53 | 56 |
| Pages occupied by Manufacturing | 482 | 450 | 514 |
| Production articles | 28 | 31 | 35 |
| Pages occupied by Production | 212 | 296 | 316 |
| Manufacturing-Production | 8 | 10 | 6 |
| Pages occupied | 66 | 80 | 62 |
| *Classification of Reviews* | | | |
| Manufacturing Reviews | | | 5 |
| Pages occupied by Manufacturing Reviews | | | 144 |

2. *Abstracts.*

You will note a substantial increase in the number of pages of abstracts

during the past year. We believe also that the quality of the work done has been improved. Steps have recently been taken to make further improvements particularly in reference to uniformity in the citation.

3. *Style Standard.*

The committee on Style Standard has made their report to the Editor and Journal Management Committee. A "Note to Contributors" has been prepared which we trust will be mutually helpful to author and editor. It is intended that this shall be printed on one Journal page in small type and regularly carried in the Journal.

Again we want to take this opportunity to publicly express our gratitude to all those who have given so generously of their time and energies in our assistance. To them is due the credit for any measure of success attained.

The following action was taken by the Board of Directors:

1. The Editor's report was accepted.
2. The Secretary was instructed not to publish a list of the members in the December Journal.
3. The budget was made for a period of 18 months.
4. Student branches were authorized at Cornell and Oklahoma.
5. From the report of the Committee on Journal Management:
   - A. The twenty-year index is to be sold at cost, which is approximately $4.50. Pre-publication price to members is to be $1.00; after-publication price, $2.00. The Secretary was authorized to place the pre-publication price on annual statements.
   - B. Approve policy adopted last year in paying for abstracts.
   - C. Abstracts of papers presented at annual meeting are to be published in the August Journal.
   - D. The report of the Committee on Style Standards was adopted and ordered printed.
   - E. The pages per volume of the Journal should not exceed the present number.
6. Report of Auditing Committee was accepted.
7. The Secretary-Treasurer was authorized to send a copy of the minutes of the Board of Directors to each officer and director, and to condense the minutes that are to be printed into about 15 pages. He was further authorized to make a very brief report of all board action at the General Business Session.
8. The following report of the Committee on Divisions was accepted:
   - A. That each of the three divisions be paid $25.00 upon receipt of a report of their meeting, and the names of the elected officers for the ensuing year.

B. That the divisions hold their election by ballot of those members who attend the divisional meetings.

9. That the $1,025 collected by Professor Borland be turned over to the Chairman of the Awards Committee of the Production Section when requested.
10. Texas was selected for the 1943 meeting.
11. The tentative program of the next annual meeting is to be printed separate and distributed with the May issue of the Journal.

## AMERICAN DAIRY SCIENCE ASSOCIATION PRESENTED BORDEN AWARDS

TO

## P. F. SHARP

AND

## E. B. HART

*University of Vermont*

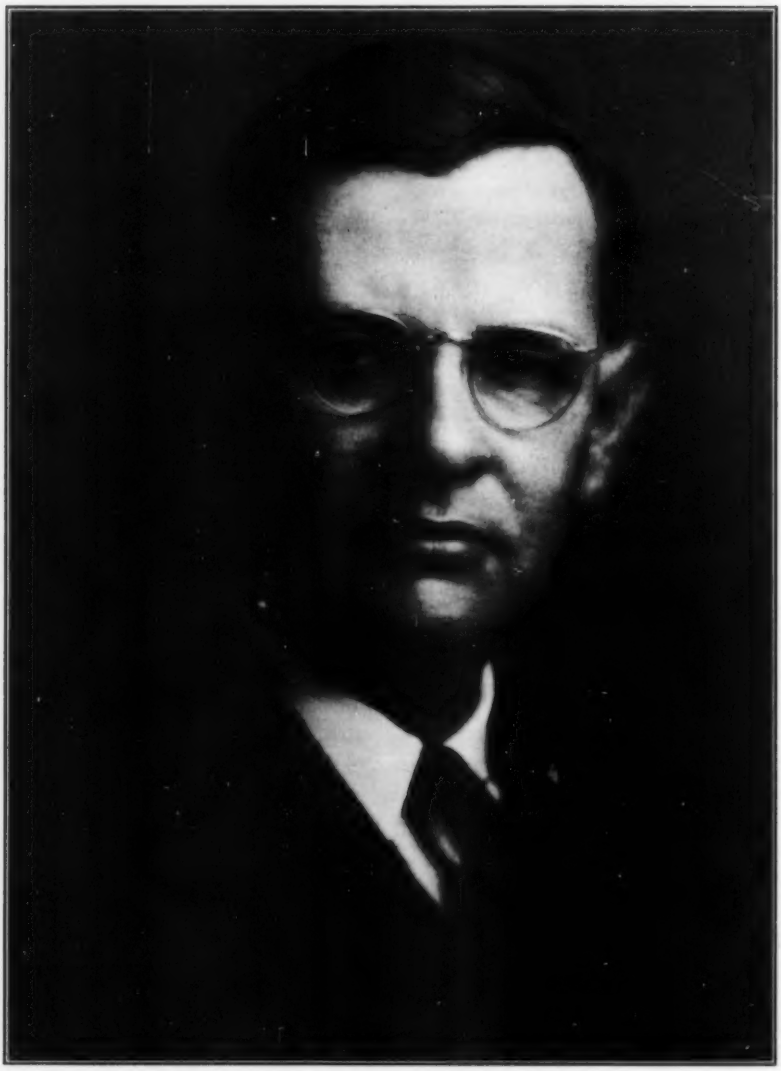
*Burlington, Vermont, June 26, 1941*

Mr. H. B. Ellenberger acted as toastmaster at the Annual Association Banquet, and presented Gov. William H. Wills of the State of Vermont, Dean J. L. Hills of the University of Vermont's Agricultural College, and Mr. W. D. Dotterer, acting chairman of the Committee for the Borden Award in Dairy Manufactures.

Mr. Dotterer made the following statement:

"Corporations are not always the soulless organizations they have been accused of being. There are times when they show more humanitarian characteristics than some of the individuals who make the unwarranted accusations. This meeting is the result of far-sighted scientific appreciation by one of the large corporations engaged in the dairy business. They are under no obligation to industry or to the universities to provide a prize for outstanding work in dairy investigation or development, but they have generously provided two $1,000 awards for such effort. May I take this opportunity to express the appreciation of the American Dairy Science Association to the Borden Company for this generosity in providing this very substantial gift to one of our great scientists.

"I do not suppose that any of the scientists engaged in dairy research have been influenced in the quality or quantity of their work by the thought of the Borden Award. Rather they pursue their labors with the object of learning the truth and making their work available to their colleagues and to the whole industry. If this statement seems doubtful, one need only note the number of new and improved processes which have been given to any who would use them for the benefit of humanity.



PAUL FRANCIS SHARP

"The man chosen to receive the award in dairy manufacture this year is well known to every one interested in the scientific aspects of dairying. He has been the inspiration and leader in a great number of important

researches. He is recognized as one of the best dairy scientists in the world. He is one of the quiet, unassuming, gentlemanly personalities whom it is a delight to know and to work with. His statements are carefully made and can be taken for facts. All I have said can be applied to many other investigators in the dairy field. In fact, the first impression made on the Committee when the data on so many men was presented for consideration was that a choice would be well night impossible. However, after much deliberation, a choice has been made. The Committee hopes and believes that out of the galaxy of stars a selection has been made with which you will agree. We know the successful nominee is worthy of the prize and only regret that more prizes were not available.

"It is not my duty to make a speech but to name the recipient of the Borden Award in Dairy Manufactures for 1941. He is Paul Francis Sharp of Cornell University. Dr. Sharp received his Bachelor of Arts degree at Nebraska Wesleyan University in 1917, his Master of Science at the University of Minnesota in 1920 and his Doctor of Philosophy at the University of Minnesota in 1922. He was student assistant in Chemistry at Nebraska Wesleyan and the University of Minnesota 1917–1922; also in chemical warfare service, U.S.A., 1918. He was associate chemist at Montana Agricultural Experiment Station 1922–25. He has been Professor of Dairy Chemistry and chemist in the Agricultural Experiment Station of Cornell University since 1925.

"Dr. Sharp is one of those tireless workers who have given so much to the Dairy Industry. His publications are legion and the information he has furnished has been of inestimable value commercially. It is not easy to say which of his accomplishments have been of the greatest use to dairying and to humanity. Studies on the lipolytic activity of milk in relation to flavor, studies on Vitamin C, studies on oxidized flavor, studies on the physical state of milk fat and studies on the de-aeration of milk are some of the projects which have helped to make him so well known.

"The Committee unanimously chose him as the most deserving and it is my privilege to present to you, Mr. Wentworth, Dr. Paul Francis Sharp, in order that you may give him the really substantial part of the award."

Mr. Sharp came to the platform, and Mr. W. A. Wentworth of the Borden Company presented Mr. Sharp a gold medal and a check for $1,000.

Mr. Ellenberger, the toastmaster, then introduced Mr. G. C. White, acting chairman of the Committee for Borden Award for Production. Mr. White then made the following statement:

"The three members of the Production Award Committee, whose duty it was to select the recipient of the 1941 Borden Award for outstanding research in dairy production, have unanimously chosen Professor Edwin Bret Hart of the Wisconsin College of Agriculture for this honor. Professor

Hart's numerous contributions to our scientific knowledge and his service to the dairy industry over the last 40 years mark him as the outstanding candidate for this award.

"Professor Hart was born December 25, 1874, at Sandusky, Ohio. He received his B.S. degree from Michigan in 1897 and later attended the Universities of Heidelberg, and Marburg, Germany, in 1900–1901. His first

EDWIN BRET HART

position in this country was with Dr. L. L. Van Slyke of the New York Experiment Station at Geneva, where he was assistant chemist from 1897 to 1902 and associate chemist from 1902 to 1906. He was appointed Professor of Biochemistry and Chairman of the Department of Biochemistry at the University of Wisconsin in 1906, which positions he holds today.

"Among the numerous meritorious contributions to fundamental dairy knowledge which the Committee found in Professor Hart's record, the following are cited as deserving of special mention:

"(1) The determination of phosphorus in feeds and the rôle of phosphorus in nutrition of animals. Also his work on the chemical changes which take place in ripening cheese. This work is the most complete and significant that has ever been done on this subject.

"(2) The relationship of copper and iron for building blood hemoglobin, in the prevention or cure of nutritional anemia.

"(3) The importance of minerals other than iron and copper in animal nutrition, especially phosphorus and its availability from both organic and inorganic sources; iodine in the prevention of goitre, referred to as 'big neck' in ruminants; and magnesium as supplied by dolomitic limestone, which is the prevailing limestone in many parts of the country.

"(4) A fuller understanding of the function of protein in dairy and livestock nutrition, the supplementary relationships of proteins from different plant and animal sources, and the place of simple forms of nitrogen such as urea and ammonium compounds as sources for protein building. Few research men in any country have done more effective work than Professor Hart in the protein nutrition of dairy cattle.

"(5) The existence of the 'grass juice factor' in animal nutrition, which has particular reference to summer milk, and to winter milk which has been produced on superior roughages.

"(6) The favorable effect of fat on the utilization of lactose in milk.

"(7) The superior value of butterfat over vegetable oils, through virtue of certain essential fatty acids.

"Last, but not the least, the Committee wishes to call especial attention to Professor Hart's leadership in training scientists. Many brilliant young men have sought an opportunity to work with Professor Hart in his laboratory at Madison. Many of these Hart-trained men are now leaders in many experiment stations and in industry."

In the absence of the recipient, Mr. Gus Bohstedt of the University of Wisconsin, was called to the platform. Mr. W. A. Wentworth of the Borden Company presented Mr. Bohstedt the gold medal and a check for $1,000 and requested him to carry it to his colleague, Professor E. B. Hart.

Mr. Wentworth then gave a summary of the awards granted during the past five years and assured the Association of their continuation for at least one more year.

VOLUME XXIV AUGUST, 1941 NUMBER 8

# JOURNAL OF DAIRY SCIENCE

Published by the
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R. B. STOLTZ, Sec.-Treas.
Ohio State University, Columbus, Ohio

# ABSTRACTS OF LITERATURE

T. S. SUTTON, Editor
Columbus, Ohio

## MILK AND MILK PRODUCTS

Published in cooperation with
INTERNATIONAL ASSOCIATION OF ICE CREAM MANUFACTURERS
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A. J. POWERS, Brooklyn, New York, I. A. M. D.

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## JOURNALS

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American Milk Review
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American Journal of Physiology
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Biochemische Zeitschrift

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Canadian Public Health Journal
Certified Milk
Cornell Veterinarian

Dairy Industries
Dairy World
Deutsche Molkerei Zeitung

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Food Industries
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Ice Cream Review
Ice Cream Trade Journal
Industrial and Engineering Chemistry

Journal of Agricultural Research
Journal of Agricultural Science
Journal of American Veterinary Medical Association
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Zeitschrift für Infektionskrankheiten Parasitäre Krankheiten und Hygiene der Haustiere
Zeitschrift für Physikalische Chemie, Abt. A and B
Zeitschrift für Untersuchtung der Lebensmittel
Zeitschrift für Züchtung. Reihe B. Tierzuchtung und Zuchtungbiologie
Zentralblatt für Bacteriologie
Züchtungskunde

## SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copehagen, Denmark

United States Department of Agriculture

# ABSTRACTS OF LITERATURE

## ADVANCE ABSTRACTS OF REPORTS ACCEPTED FOR PUBLICATION

**478. The Relationship of pH to Some Curd Characteristics of Modified Milks.** ARNOLD B. STORRS, American Seal-Kap Corporation, Long Island City, N. Y.

A study has been made by means of the Chambers-Wolman "artificial stomach" test of the effect of variations in pH upon the curd surface area, the bulkiness and the completeness of curd formation of some commercially modified milks. The curd surface area of any milk appears to be lowest at the highest pH level at which complete coagulation will first appear, while at any pH below that required for complete coagulation the curd surface area increases as the pH is lowered. The effect of pH upon the bulkiness or completeness of curd formation is variable in milks modified by different processes and the method of modification seems to be the most important factor in determining the relationship. Because of the varying response of different types of milk there does not seem to be any single pH level which, in view of our present knowledge, would be suitable for comparative *in vitro* tests on all milks.

**479. Observations on Delayed Salting of Brick Cheese.** W. L. LANGHUS AND W. V. PRICE, University of Wisconsin, Madison.

Manufacturers have attempted to hasten the ripening of Brick cheese by delaying the salting operation for several days. Existing information indicates that this treatment may affect the rate of curing as well as flavor, body, texture, and color finally attained. The idea was investigated by salting, at intervals of 1, 5 and 9 days after manufacture, cheese made from either raw or pasteurized milk.

When the salting of cheese is delayed there is an improvement in cheese body apparent at two weeks of age, but this advantage eventually disappears and the general quality of the cured cheese is not as good as that of the cheese salted in the normal manner. The delayed salting does not materially affect the amount of salt incorporated in the cheese nor the acidity of the cheese during ripening but it does increase the loss of moisture during the first two weeks of curing. The differences in body apparent during this interval are attributed to changes in the protein rather than to differences in cheese composition.

Normal addition of salt soon after making establishes conditions favorable to the development of desirable flavor and body. Delayed salting, as practiced in these experiments, has no lasting benefits to commend it to the Brick cheese industry.

**480. A Double Change-over Design for Dairy Cattle Feeding Experiments.** W. G. COCHRAN, K. M. AUTREY, AND C. Y. CANNON, Iowa Agricultural Experiment Station, Ames, Iowa.

During the winter of 1939–40, a short-time feeding trial, of the double switch-over type, was carried out on eighteen Holstein cows, with three planes of feeding: roughage, limited grain and full grain. Every cow received each ration in turn for a period of six weeks, while in any period one-third of the cows were receiving a given ration, so that differences between the milk yields of different cows and differences between the average yields for the three periods did not contribute to the experimental errors. With this design accurate comparisons between the effects of the three rations were obtained.

The design also made it possible to estimate the sizes of the carry-over effects of the rations from one period into the succeeding period, and to adjust for these where necessary. By failure to adjust for carry-over effects on the yields of fat-corrected milk, the differences between the rations would have been underestimated by about 11 per cent.

The computations required to estimate the experimental errors are illustrated by using the results for total nutrient consumption, where there appeared to be no carry-over effects, and for fat-corrected milk, where an adjustment for carry-over effects was necessary.

A corresponding design for comparing four planes of feeding is briefly discussed.

**481. Estimation of Initial Live Weight at Each Lactation of Dairy Cows.** W. L. GAINES, Illinois Agricultural Experiment Station; H. P. DAVIS AND R. F. MORGAN, Nebraska Agricultural Experiment Station.

From measurements of chest girth and live weight at the Nebraska Station an equation has been derived for estimating initial live weight, that is, within the first 31 days after calving. The equation is $W = .342(G + g)^{1.85}$ in which W is weight in pounds, G is chest girth in inches, and g is an age-breed girth modifier, ranging from zero for Jersey cows under 3 years of age up to 9 for Holstein cows 5 years or more of age. A table, based on the equation, is printed on the case of the stock 96-inch steel tape rule used to measure the girth. As compared with the present scale the scale of the New York girth-weight tape grossly overestimates the weight at large girths and grossly underestimates it at small girths.

**482. The Effect of Processing on the Nitrogen Distribution in Milk.** S. G. MENEFEE, O. R. OVERMAN, AND P. H. TRACY, Department of Dairy Husbandry, University of Illinois, Urbana, Illinois.

Semimicro methods were used to make a preliminary investigation of the

nitrogen distribution in processed milk products and determine the routine applicability of semimicro methods for separating and analyzing the N fractions of milk.

The homogenization of milk at normal and abnormal pressures produced no significant changes in the N distribution.

The coagulation of albumin and globulin was the most significant change that occurred in the N distribution of evaporated milk. Evidence is presented to indicate that some hydrolysis of the proteins takes place in this product as a result of the processing.

Condensing skim milk produced only minor changes in the N distribution and the addition of Steapsin, Trypsin, and Enzylac to milk produced definite hydrolysis of the milk proteins.

The semimicro methods used for the analytical determinations were found to be efficient, well adapted to routine analysis and results compared very favorably with those obtained by the official methods.

**483. Pseudomonas putrefaciens in Dairy Plant Equipment.** H. F. Long and B. W. Hammer, Iowa State College, Ames.

*Pseudomonas putrefaciens*, which is a common cause of the putrid defect in butter, was isolated from churns and from the insulation of a leaky vat. At certain points the organism was present in considerable numbers. In addition to *Ps. putrefaciens*, micrococci, spore forming bacteria, gram negative rods and often yeasts and molds were present.

**484. Oxidized Flavor in Milk IX. The Effect of the Quality of Hay and Early Stage of Lactation on the Carotene Content of Butter Fat and the Ascorbic Acid Content of the Milk and Their Relationship to the Development of Metal-Induced Oxidized Flavor.** W. Carson Brown, A. H. VanLandingham, and Chas. E. Weakley, Jr., West Virginia Agricultural Experiment Station, Morgantown.

A study of oxidized flavor in milk produced on different qualities of alfalfa hay revealed very little relationship between the carotene content of the butter fat and the intensity of the oxidized flavor developed. Likewise, no relationship was found between the ascorbic acid content of the milk and the intensity of the oxidized flavor developed. A study of the early stages of lactation revealed that the ascorbic acid content of the milk at the beginning of lactation was relatively low and increased for approximately seven to eight weeks after which it remained fairly constant. The carotene in the butter fat decreased during the first few weeks of lactation, while the intensity of oxidized flavor remained fairly constant. As the result of 580 observations (each observation consisted of three determinations per week) on the ascorbic acid content of the milk, and 555 observations (each observation

represents a composite of three samples per week) on the carotene content of the butter fat it was concluded that:

1. The feeding of high quality alfalfa hay together with alfalfa leaf meal increased, somewhat, the carotene content of the butter fat and greatly reduced or eliminated the tendency for metal-induced oxidized flavor to develop.

2. The feeding of brown, leafy alfalfa hay resulted in a decreased carotene content in the milk but did not increase the intensity of the oxidized flavor.

3. The carotene content of the milk fat at the beginning of lactation appears to be high and decreases until it reaches a normal level a few weeks after parturition.

4. The ascorbic acid content of milk at the start of lactation is usually low and increases gradually until it reaches a maximum level at about seven or eight weeks following parturition.

5. From the results obtained it appears that ascorbic acid in the milk plays a minor role in the susceptibility of the milk to metal-induced oxidized flavor.

6. The results of this study indicate that the amount of carotene in the butter fat may not be the substance responsible for the reduction in susceptibility of milk to oxidized flavor. It appears that some substance or substances associated with carotene probably has a greater effect than the carotene itself.

**485. A New Diluent for Bovine Semen.** C. E. KNOOP, Dairy Department, Ohio Agricultural Experiment Station, Wooster, Ohio.

A diluent for bovine semen which contains gelatin (Knox), egg yolk, buffer salts, and water has been found, under improved conditions, to maintain the motility of the spermatozoa as follows: After two to four days in storage the motility averaged 73 per cent (range 57 to 83 per cent); motility after 12.5 days was 50 per cent; and motility after 17.5 days was 25 per cent. Some cell life was observed for an average of 26.5 days (range 16 to 35 days).

The motility of a comparable group of semen samples diluted with a diluent containing egg yolk, buffer salts, and water averaged after two to four days in storage 59 per cent (range 33 to 80 per cent), after 8.3 days, 50 per cent, and after 14.5 days, 25 per cent. Some sperm life remained for an average of 26 days (range 14 to 38 days).

## BACTERIOLOGY

**486. The Maintenance of Pure Cultures of Lactic Acid Bacteria.** J. G. DAVIS, Dairy Indus., *6:* 8. 1941.

A detailed consideration of pure cultures of lactic acid bacteria including isolation, media, routine maintenance, contamination, detecting contami-

nation, purification and recovery of apparently dead cultures. Methods and techniques are described for isolation and maintenance of such cultures.

D.V.J.

**487. Bacteriology of Dairy Water Supplies.** A. L. PROVAN, Dairy Indus., *6:* 65. 1941.

Farm and dairy water supplies should be of a standard equal to that demanded for domestic usage and in addition should not contain organisms which are liable to cause rapid deterioration in dairy products. The beneficial effect of proper protection of farm water supplies is demonstrated by a bacteriological study in which farm waters were analyzed before and after protection.

Although chlorination is the simplest method of control, it does require considerable technical control and is frequently more costly than other control measures. D.V.J.

**488. A Presumptive Test for the Oral Contamination of Drinking Utensils.** LEO A. DICK AND G. J. HUCKER, Dept. of Bacteriology, N. Y. State Agr. Exp. Sta., Geneva, N. Y. Jour. Milk Tech., *3:* 307–313. 1940.

"Total bacterial count" of eating utensils gives inadequate information as to the sanitary condition of eating and drinking utensils. More attention must be given to qualitative methods for determining the sanitary condition of such utensils.

A procedure is given for the detection of oral contamination of drinking glasses. Conclusions arrived at in this study were as follows:

The presence of *Streptococcus salivarius* on the rims of drinking glasses indicated that the glasses had not been properly washed after use. This organism was recovered from the closed lips of each of 100 persons tested; and without exception, in 100 controlled cases the organism was deposited on the rims of glasses during use.

When glasses are not cleaned or sterilized after use, this organism was found to survive thereon for at least 48 hours.

A cold water rinse following use will not remove this organism, neither will a double rinse of water at 120° F. be adequate.

A soap water wash (pH 8.6) at 120° F. followed by a rinse in clear water at 165° F. for five minutes will do the job providing the contamination is not too great.

The presence of this organism on the rims of drinking glasses is an indication of previous oral contamination. L.H.B.

**489. The Effect of Variations in the Fat Percentage and in the Reaction (pH) of Milk Media on the Heat Resistance of Certain Milk Bacteria.** AGNES A. NICHOLS, The Hannah Dairy Res. Inst., Kirkhill, Ayr., Scotland. Jour. Dairy Res., *11:* 274–291. 1940.

A comparison was made of four different types of containers, namely, (a) glass capillary tubes, (b) glass ampoules or bulbs, (c) glass Pasteur pipettes and (d) corked test tubes as a container for the inoculated substrate for heat resistance tests. The cork test tube was considered most satisfactory. Two strains of *B. subtilis* which had produced bitterness and thinning in canned cream were used in a study of the effect of the reaction on their destruction by heat. The results expressed as percentage survival were inconclusive over the range studied, pH 5.95 to 7.0 in one case and pH 6.1 to 7.25 in another. No consistent differences in survival percentages were noted using substrates of skim milk, whole milk, 10 per cent butterfat cream and 23 per cent butterfat cream. S.T.C.

**490. The Microbiology of Silage Made by the Addition of Mineral Acids to Crops Rich in Protein. II. The Microflora.** A. CUNNINGHAM AND A. M. SMITH. College of Agr., Edinburgh, Scotland. Jour. Dairy Res., *11:* 243–265. 1940.

The microflora of A.I.V. silage was found to consist mainly of lactic acid bacteria—lactobacilli, streptococci, micrococci and sarcinae. A detailed study was made of some 70 strains. The characteristics which the authors considered to be most valuable for the differentiation of the organisms were ability to produce carbon dioxide, percentage of lactic acid formed and lactic, acetic acid ratio.

Among the lactobacilli, both homo- and heterofermentative types were represented. The former included strains of *Lactobacillus plantarum* (Orla-Jensen) Bergey *et al.* and in the heterofermentative group *L. brevis* (Orla-Jensen) Bergey *et al.* was found. Cultures of a motile homofermentative lactobacillus were isolated. This was considered to be a new type.

The homofermentative streptococci were found to belong to the *Streptococcus lactis* group; and the heterofermentative forms were identified with *Leuconostoc mesenteroides* (Cienkowski) van Tieghem.

Streptococci, micrococci and motile lactobacilli were found mainly in fodder recently ensiled, while the majority of the lactobacilli and sarcinae were associated with the older samples. S.T.C.

## BREEDING

**491. Causes of Variation in Milk and Butterfat Yield of Dairy Cows.** IVAR JOHANSSON AND ARTHUR HANSSON. (In English) Jour. Roy. Swedish Acad. Agr., Jahrg., *79*, No. 6½. 127 pp. 1940.

Some 7,000 lactation records from 3,000 cows in 13 herds of Swedish Red

and White cattle were studied to measure the importance of various non-genetic factors (such as age, dry period, length of calving interval, etc.) and of genetic differences in causing milk and fat production to be high or low. Correction factors for the more important recorded non-genetic factors were devised. Intra-herd repeatability of differences in single lactation records was + .36 among the corrected records of some 300 cows which each had at least five records. The Intra-herd correlation between fat percentage and milk yield was − .17 but averaged practically zero within groups of records by the same cow. The genetic portion of the variance in single records was estimated to be: 70 to 80 per cent for fat percentages, 30 to 40 per cent for total milk or fat yield, 15 to 30 per cent for persistency, and zero to 5 per cent for length of calving interval. J.L.L.

## BUTTER

**492. Butterschmalz, eine nationale fettreserve. (Butter Oil, a National Fat Reserve.)** H. BALLHOFER. Deut Molkerei. Ztg., *44*, 1443–1444. 1939.

This article explains mass production of butter oil. Originally this procedure was a small scale operation. Today because of a national emergency it is urged that the operation be adjusted to a daily capacity of 400,000 pounds at large plants. This huge capacity is suggested so as to quickly convert butter stocks into oil as a vitamin saving venture. J.C.M.

**493. Versuche über Herstellung und Haltbarkeit von Butterschmalz. (Experiments Dealing with the Manufacture and Keeping Quality of Butter Oil).** M. SCHULZ AND W. STORCK. Deut. Molkerei Ztg., *9:* 29 and continued in *10:* 143–145, and in *11:* 166–167. 1940.

Butter oil was obtained by mixing butter with water and centrifuging it. Some was centrifuged at 57° C. (134.6° F.) and then heated to 90° C. (194° F.). This kept well in cold storage for 2 years.

It was discovered that 15° C. (59° F.) was a better storage temperature than 5° C. (41.9° F.) for butter oil. At the lower temperature of storage texture defects were observed.

It was also recommended to add .5 per cent of oat flour to the butter oil to be stored. J.C.M.

**494. Die Verbutterung von Süszrahm und die Verwendung der süszen Buttermilch in der Käserei. (The Churning of Sweet Cream and the Use of Sweet Buttermilk in the Cheese Factory.)** W. RIEDEL. Deut. Molkerei Ztg., *2:* 11 and continued in *3:* 18. 1940.

The author reviews briefly the history of sour cream butter in Southern Germany. He emphasizes the fact that this butter is typically oily, metallic and sometimes fishy in flavor.

Experiments were conducted churning at pH 5 to avoid the flavor defects and achieve the sour cream butter aroma. This was achieved by adding 2 per cent of culture at churning time, allowing no time for acid development. The cream best suited for this contained 35 to 40 per cent of fat. Churning was at 4° C. (39.2° F.); and the buttermilk was at 9° C. when drawn from the churn.

The above procedure gave a sweet cream buttermilk high in fat. This was very suitable for mixing with milk to make a 20 per cent fat Edam type cheese. It required 20 per cent of buttermilk and a setting temperature 2° higher to achieve good results with this procedure. A high fat content Edam type cheese was made with 20 per cent of buttermilk added to normal milk fortified with cream.

The cheeses made from sweet buttermilk and whole milk were equal in quality to the orthodox skim milk and milk mixture made cheeses.

Romadur and semi-soft surface ripened cheeses were also made successfully with the sweet cream buttermilk—milk mixtures, which by itself had little value for cheese purposes. J.C.M.

**495. Keeping Quality of Butter.** O. F. HUNZIKER, La Grange, Ill. Natl. Butter and Cheese Jour. *32*, No. 5: 12. May, 1941.

Keeping quality is attained best by using high quality cream; by eliminating contamination through adequate plant and equipment sanitation and proper pasteurization; by thorough working of butter; and by protecting cream and butter from contact with iron and copper surfaces. Salted butter made from high acid cream is more susceptible to chemical deterioration than unsalted butter; the latter is more easily damaged by bacteriological changes. Ripening cream to .35 to .45 per cent acidity improves the keeping quality of unsalted butter. This type of butter keeps well in −15° F. storage but at temperatures above freezing deteriorates more rapidly with increasing temperatures. W.V.P.

## CHEESE

**496. Pultost, (Ramost).** L. FUNDER. Meieriposten, *20:* 360–361. 1940.

This article describes Pultost (Ramost) a Norwegian cheese little known and made from skimmilk and milk.

The skimmilk is mixed with 10 per cent of whole milk and cultured with 2 per cent of starter for several days. The acidity usually reaches .7. At this point the mixture is heated slowly to 55–60° C. (131–140° F.) and held for several hours. It is then drained. Salt is added at a 4 per cent rate and caraway is added in small dosages. The cheese is consumed when fresh or after aging. It is a rare cheese and only consumed by occupants of thinly settled regions. J.C.M.

**497. Studies on the Chemistry of Cheddar Cheesemaking. VII. The Measurement of the Acidity of Cheese and the Relation of Acidity to Grading Score.** R. M. DOLBY, F. H. MCDOWALL, AND W. RIDDET, Dairy Res. Inst. (N. Z.), Palmerston North, New Zealand. Jour. Dairy Res., *11:* 305–310. 1940.

Data were secured on 420 cheese comprising a complete season's make at the institute experimental factory. The pH of cheese at 14 days old was considered to be the most useful means of measuring the extent of acid development in the cheese. Values on younger cheese were less stable because the acidity was still increasing. A fair agreement was found between extent of acid development as indicated by pH of the 14-day old cheese and observations of the graders on the mature cheese. Cheese with a pH value of 4.90 at 14 days received the highest average score at maturity. S.T.C.

**498. What About Foreign Type Cheese?** H. G. LINQUIST, Mass. State College, Amherst, Mass. Natl. Butter and Cheese Jour., *32*, No. 5: 16. May, 1941.

Cheese consumption has increased since 1934 and recently imports have been reduced. Swiss cheese of good quality must and can be made in the United States. Roquefort type made from cow's milk is being made and cured successfully in abandoned coal mines and sandstone caves. Domestic Edam and Gouda and Italian types of cheese are being readily accepted. American industry can make the foreign types if care is taken to study markets and practice the best methods of manufacturing and curing.

W.V.P.

**499. Practical Suggestions on the Use of Rennet.** M. W. HALES, Chris Hansen's Lab., Milwaukee, Wis. Natl. Butter and Cheese Jour., *32*, No. 4: 26. 1941.

Many factors affect formation of curd by rennet; among them are temperature of coagulation; salt content of the milk, particularly calcium; use of milk from diseased udders; per cent of casein and fat in milk; milk acidity; and agitation of milk during coagulation. The rennet test, when properly used, is a good measure of change in milk acidity and can be used to compare strength of two lots of rennet when identical milk and coagulation temperatures are used for the tests. Good commercial rennet extract kept in a closed vessel decreases in strength 3 per cent per month in a warm room; in a cool cellar it loses 1 per cent per month; and in cold storage the loss is even less. If temperatures are too high the rennet may spoil. The container used to measure cheese color should be rinsed out before using it to measure rennet beause alkaline cheese color weakens rennet action.

W.V.P.

**500. The Influence of "Mastitis" upon the Yield and Quality of Cheddar Cheese.** C. K. JOHNS, T. J. HICKS, AND C. A. GIBSON, Dept. of Agr., Ottawa, Canada. Jour. Dairy Res., *11:* 298–304. 1940.

Milk from the animals in the Central Experimental Farm herd was grouped as follows:

A. Normal—negative daily strip-cup record; no evidence of bacterial infection; catalase low.

B. Abnormal—strip-cup record negative or rarely mildly positive; frequent high values for catalase and pH; *Str. agalactiae* absent from repeated samplings.

C. Agalactiae—*Str. agalactiae* previously isolated from milk on at least two occasions; strip-cup rarely positive; latent infection with no pathogens detected during experimental period.

The yield of Cheddar cheese from the milk classified as normal was greater than that from the other groups. Evidence was secured indicating that the lowered yield resulted from the lower casein and solids-not-fat contents of the "mastitis" milks.

With a single exception the cheese made from these "mastitis" milks were not inferior in quality to those made from the normal milks. S.T.C.

## CHEMISTRY

**501. Untersuchungen über die Genauighkeit der Milchfettbestimmung nach dem Gerber-Verfahren und ihre Grenzen (Studies Dealing with the Accuracy Obtained in Fat Analyses by the Gerber Method).** G. ROEDER, Milchw. Forsch., *20:* 200–256. 1940.

The author studied the accuracy of the glassware used in the Gerber Test. He also studied the practical use of this test which is being universally used for fat analyses.

It was possible to obtain results that checked closer than 0.1 per cent. However, 0.1 is set as the acceptable variation in duplicate samples. Occasionally duplicates varied as much as 0.25 per cent.

This study is a duplicate of like studies conducted in the United States with the Babcock Method. The percentage of accuracy as measured is quite comparable for both tests. J.C.M.

**502. A Spectroscopic Method for the Quantitative Estimation of Vitamin D.** NICHOLAS A. MILAS, ROBERT HEGGIE, AND J. ALBERT RAYNOLDS, Mass. Inst. Tech., Cambridge, Mass. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 227–231. 1941.

Two new and independent procedures for the estimation of vitamin D in fish liver oils are described. One is based on the spectrophotometric esti-

mation of the extinction coefficients at 500 to 520 mμ of the color produced when the vitamin D of the fish oil in chloroform is added to a solution of antimony trichloride in chloroform. Corrections are made for the presence of sterols and vitamin A, both of which interfere with the vitamin D adsorption band. The second method is based on a chemical treatment of the non-saponifiable fraction of fish liver oils with maleic anhydride to destroy vitamin A, carotenoids, and possibly 7-dehydrocholesterol. The vitamin D in the treated non-saponifiable portions is estimated spectrophotometrically. The results are considered to be in fair agreement with the biological. B.H.W.

**503. Chemical Estimation of Nicotinic Acid and Vitamin $B_6$.** HARRY A. WAISMAN AND C. A. ELVEHJEM, Univ. of Wis., Madison, Wis. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 221–225. 1941.

A review of the factors involved in the chemical determination of nictonic acid and of vitamin $B_6$ is presented. Chemical methods for the estimation of nicotonic acid depend upon a breakdown of the pyridine ring structure generally with cyanogen bromide and conjugation of the carbon chain with an aromatic amine, generally aniline. The color formed from nicotinic acid, cyanogen bromide and an amine is highly specific. The conditions of the reaction are discussed and it is concluded that the method can be applied with a fair amount of success to the determination of nicotinic acid in animal tissues, urine and blood but it is not so well adapted for use in the analysis of plant materials. The chemistry of three methods for the determination pyridoxine (vitamin $B_6$) is discussed and equations for the reactions are presented. B.H.W.

**504. Chemical Methods for Determination of Vitamin C.** C. G. KING, Univ. of Pittsburgh, Pittsburgh. Pa. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 225–227. 1941.

Most of the methods for the estimation of vitamin C are based on the reversible oxidation of ascorbic acid to dehydroascorbic acid. The reaction of ascorbic acid with 2, 6-dichlorophenolindophenol can be used in direct titrations or with the photoelectric colorimeter with satisfactory results. Other methods are available for use under special circumstances. Methods for the measurement of dehydroascorbic acid are subject to the interfering reaction of many aldehydes, ketones, and quinones. Three methods for detecting and avoiding such interference are pointed out. B.H.W.

**505. Chemical Methods for Determination of Vitamin B.** DOUGLAS L. HENNESSY, Fordham Univ., New York, N. Y. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 216–218. 1941.

In a review of methods for the determination of Vitamin $B_1$ it is con-

cluded that accurate and rapid chemical methods are available for the determination of this vitamin. B.H.W.

**506. Recent Developments in Methods for Determining Carotene.** WALTER J. PETERSON, Kansas Agr. Exp. Sta., Manhattan, Kansas. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 212–216. 1941.

Improvements in methods for the extraction and quantitative determination of β carotene in dry and fresh plant tissue are described. Solvent and adsorption methods for the separation of β carotene from accompanying petroleum-soluble carotenoids are discussed. Refinements in the technique of column preparation in chromatographic adsorption are presented.

B.H.W.

**507. Photoelectric Photometer for Vitamin A Estimation.** ALLAN E. PARKER AND BERNARD L. OSER, Electrical Testing Labs., New York, N. Y., and Food Res. Labs., Long Island City, N. Y. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 260–262. 1941.

An instrument for determining the spectral absorption of light in the utra-violet and by which a rapid and accurate estimation of vitamin A can be made is described. Static conditions are maintained in an electrometer tube by holding the grid potential at a constant value. This is done by the use of a slide-wire potentiometer. The readings on the calibrated slide wire give either the transmission of the cell and material or the extinction coefficient. The instrument is economically constructed, readily portable and by the use of a wide range of light sources and filters it may be used for making transmission measurements in other ranges of the ultra-violet. B.H.W.

**508. Determination of Vitamin $B_2$ (Riboflavin). Comparison of Bioassay, Microbiological, and Fluorometric Methods.** A. D. EMMETT, O. D. BIRD, R. A. BROWN, GAIL PEACOCK, AND J. M. VANDENBELT, Res. Lab., Parke, Davis & Co., Detroit, Mich. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 219–221. 1941.

The results of a comparative study of four methods for determining vitamin $B_2$ are presented. The methods were applied concurrently to several samples varying in type, composition, and potency. The four methods, biological rat growth, visual fluorescence, photoelectric fluorescence and microbiological by both culture turbidity and acidimetry gave similar results. The greatest differences were with the low-potency samples. The microbiological method showed excellent specificity and reproducibility and the results of measurements of culture turbidity at 24 hours and of acidimetry at 72 hours incubation were almost identical. B.H.W.

**509. Physical and Chemical Determination of Vitamin A.** J. B. WILKIE, U. S. Food and Drug Admin., Wash., D. C. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 209–211. 1941.

A review of the current status of the physical and chemical methods for the determination of vitamin A is presented. The use of the antimony trichloride reaction and of ultraviolet absorption for estimation of vitamin A is discussed and factors affecting the stability of the vitamin are considered.

B.H.W.

**510. Measuring Oxidation of a Vegetable Oil.** GEORGE L. CLARK AND FRANK M. RUGG, Noyes Chem. Lab., Univ. of Ill., Urbana, Ill. Jour. Indus. and Engin. Chem., Analyt. Ed., *13*, No. 4: 243–244. 1941.

Measurement of the spreading pressure of drops of soybean oil placed on a monomolecular film on a hydrophilic balance has been used to evaluate the oxidation of the oil. The results are compared with the peroxide number and are considered to be more accurate than the peroxide number in the evaluation of oxidation. The method is probably applicable to other liquids which contain hydrophilic groups such as lubricating oil addition agents.

B.H.W.

**511. On the Use of Various Sera for the Determination of Soluble Calcium and Phosphorus of Milk.** G. T. PYNE, Dairy Chem. Dept., University College, Cork, Ireland. Jour. Dairy Res., *11:* 292–297. 1940.

The author reaches the following conclusions with respect to the value of various milk sera for the determination of the soluble phosphate and calcium of milk. Dialysis at 0–5° C. (32–41° F.) was used as the standard method:

1. Rennet whey was the most satisfactory; with fresh milk it yields fairly accurate values for calcium, slightly low (average 5 per cent) for phosphate. With increasing acidity of the milk both sets of values tend to rise somewhat relatively to those of the dialysate, phosphate approaching the true value and calcium rising slightly above it.

2. Mercuric chloride borax serum gives high results for the soluble phosphate of fresh milk. With increasing acidity of the milk, the results fall steadily.

3. Papain whey gives somewhat low results for both the phosphate and calcium of raw and pasteurized milk, with the same tendency as rennet whey to yield higher and improved results as the acidity of the milk increases. With boiled milk it gives abnormally high results for both constituents.

The additional phosphate and calcium appear to arise from the solution of colloidal calcium phosphate. S.T.C.

## DISEASE

**512. Drei Jahre Eutergesundheitskontrolle in Schleswig-Holstein. (Three Years of Udder Infection Control in Schleswig-Holstein.)** A. HEINKE. Tierzüchter, *29:* 281–283. 1940.

A total of 72,000 animals are being studied. Samples of 100 cc. size are taken from each quarter at the start and close of the milking. The control is very rigid since the war started. Vigilance is essential with the war order changes involving the use of more milking machines and personal changes. Each animal is tested twice annually.

The program also calls for points of sanitation beyond the cows.

The udder samples are inspected for evidence of mastitis. Tuberculosis and abortion are followed closely. Diseases of the cow typical of the area are also followed.

The essence of the entire program is to completely eliminate by slaughter diseased animals. J.C.M.

**513. Elimination of Streptococci from Superficial Wounds by Sulphanilamide Powder.** LEONARD COLEBROOK AND A. E. FRANCIS, Royal Army Medical Corps. Lancet, *240:* 271–273. 1940.

The moist wounds after a saline bath were sprinkled with sulphanilamide powder and covered with a moist dressing that was kept moist with a larger sheet of jaconet or oiled silk and a firm bandage. In 21 cases with Lancefield's Group A streptococci, in one case with Group C streptococci, and in 2 cases with Group G streptococci, local application with sulphanilamide resulted in permanent disappearance of the organisms. Four of these cases received simultaneous oral administration of sulphanilamide. Four cases with Group D streptococci resisted the local treatment. Neither sulphanilamide nor sulphathiazole had consistent effects on staphylococci, *B. proteus,* or *Pseudomonas pyocyanea.* J.F.C.

**514. Sulphathiazole in Treatment of Staphylococcal Infections.** GEORGE MELTON, Lewisham Hospital, London County Council. Lancet, *240:* 274–278. 1940.

In a series of 50 cases of staphylococcal infection sulphathiazole treatment appeared to be beneficial in reducing toxemia and in preventing extension of the infections. J.F.C.

**515. The Percutaneous Tuberculin Test.** F. DUDLEY HART. Lancet, *240:* 414–415. 1941.

Percutaneous tests were performed on nearly 1400 subjects of different

age-groups. Seven hundred of the subjects in the age-group of 15 and under were tested in addition by the Mantoux intradermal test. Of the remaining subjects many of the non-reactors were tested by the Mantoux test for confirmation. The patch test gave a high degree of agreement with the intradermal test with subjects under 16 years of age. With the older age-groups, the patch test became less reliable. J.F.C.

**516. Bacillus lactis aerogens Infection in the Newborn.** JEAN M. CASS. Lancet, *240:* 346–347. 1941.

An outbreak of acute infection occurring in the nursery of a maternity hospital was attributed to *Bacillus lactis aerogenes*. Of 22 infants, 5 were affected, 2 of whom died. *B. lactis aerogenes* was found in pure culture in the blood of the 2 fatal cases at autopsy and was the predominating organism in the stools of all cases. Three infants, who were acutely ill had never received breast milk, and the other 2, who suffered only mild attacks, had received only a little breast milk. All other infants in the nursery at the time were breast-fed. Although *B. lactis aerogenes* could be isolated from the stools of some of the healthy infants, it was never found as the predominating organism.

The organism was V.P. negative, M.R. negative, and citrate positive. It fermented lactose, glucose, saccharose, mannite, salicin, glycerin, cellobiose, and inosite, and failed to ferment dulcite, inulin, indole, and gelatin.

J.F.C.

**517. Subclinical Staphylococcus Mastitis in Herds Free From Streptococcus Mastitis, and Its Effect upon Milk Composition.** P. M. F. SHATTOCK AND E. C. V. MATTICK, Natl. Inst. for Res. in Dairying, Univ. of Reading, England. Jour. Dairy Res., *11:* 311–315. 1940.

The presence of haemolytic staphylococci was determined in 92 out of 428 "cow tests." Cases of staphylococcus infection were shown to be missed in mastitis control schemes based on *Str. agalactiae* infection because of suppression of growth on the routine crystal violet blood agar of Edwards. Changes in the composition of the milk were found to accompany staphylococcus infection. S.T.C.

**518. Biennial Reviews of the Progress of Dairy Science. Section E. The Diseases of Dairy Cattle.** ANONYMOUS. Jour. Dairy Res. *11:* 316–350. 1940.

This is a review of recent literature on mastitis, contagious abortion and tuberculosis. 320 references. S.T.C.

**519. The Cellular Content of Milk. Part I.** S. B. THOMAS, Dairy Indus. *6:* 41. 1941.

A survey of the literature on the general subject, with special reference to the leucocyte count and mastitis. D.V.J.

**520. A Simple, Differential Medium for Mastitis Testing.** J. G. DAVIS, Dairy Indus. *6:* 38. 1941.

A new differential medium is described and recommended for mastitis work.

Brom-cresol-purple chalk agar

| | |
|---|---|
| Peptone[1] | 3 grams |
| Yeastrol[2] | 3 " |
| Lencol[3] | 3 " |
| Lactose[4] | 5 " |
| Separated milk | 10 ml. |
| Precipitated milk[5] | 10 grams |
| Agar | 15 " |
| Brom-cresol-purple (0.04 per cent solution) | 50 ml. |
| Tap water | 1000 " |

Preparation of Medium: Dissolve the peptone, lenco, yeastrol and agar in the tap water, heat to dissolve, filter hot, adjust pH to 6.8 with brom-thymol blue using a comparitor, add the milk, lactose, chalk and brom-cresol-purple solution and fill out with constant shaking, into sterile tubes. Momentarily autoclave to sterilize.

The most valuable feature of this medium is the way the acid-forming colonies dissolve the chalk. In freshly drawn milk these are usually *Str. agalactiae.* In ordinary aged samples a number of types will form zones of clearing in the chalk.

Additional procedures, modifications and interpretation of results are also discussed. D.V.J.

**521. The Early Detection of Bovine Mastitis by an Electrometric Method.** ERNEST C. MCCULLOCH, Div. of Vet. Science, Agr. Exp. Sta., State College of Washington, Pullman, Wash. Jour. Milk Tech. *3:* 314–319. 1940.

Early detection and removal of infected animals offers the best means of control. The value of some of the tests used for detecting mastitis is discussed.

A portable electrometric device for detecting mastitis is described. This device is rapid; quarter samples can be made on about 30 cows per hour. L.H.B.

[1] Any peptone may be used.

[2] The yeast autolysates on the market are roughly of equal growth promoting value.

[3] Any reliable meat extract may be used.

[4] Dextrose may be substituted to detect those organisms fermenting dextrose but not lactose.

[5] The chalk must not be heated wet to sterilize before use. It should be sterilized by heating dry for three days at 200° C.

**522. A Study of the Mortality Rates of Calves in 335 Herds in England and Wales (Together with Some Limited Observations for Scotland).** R. Lovell, Res. Inst. in Animal Pathology, Royal Vet. College, London: and A. Bradford Hill, London School of Hygiene and Tropical Med., London. Jour. Dairy Res., *11:* 225–242. 1940.

A total of 27,970 pregnancies was recorded in England and Wales and of these 14.3 per cent failed to produce a calf surviving to the age of 6 months. The authors believe this mortality figures to be an understatement due to the disposal of bull calves often about the first or second week of life, so that their births are recorded but not their later mortality. One thousand, five hundred thirty abortions were reported, or 5.5 per cent of the total pregnancies recorded. Of the 26,440 total births recorded 1,231 or 4.4 per cent were of stillborn animals. Twelve thousand, five hundred forty-four living female calves were born and of these 693 or 5.5 per cent died before the age of 6 months.

Mortality was higher in the first half than in the second half of the year. Stillbirths and abortions were little, if at all influenced by seasonal factors.

Some observations were made on the relation of the observed calf mortality to the methods of calf husbandry. These observations indicate (a) that there is an advantage in allowing the calf to take the colostrum naturally from its mother; (b) that the mortality in these herds was not influenced by the three methods of feeding (suckling, bucket fed with undiluted milk and bucket fed with diluted milk); (c) that mortality was not influenced by the giving or withholding of water to drink.

Nearly half the deaths of female calves took place in the first week of life and three-quarters in the first month. The authors believe coli-bacillosis or white scours to have been an important cause of death. S.T.C.

## FEEDS AND FEEDING

**523. Weitere Untersuchungen über die Wirkung von Harnstoff und Glykokoll als Eiweiszersatz bei der Fütterung von Milchkühen. (Further Experiments Concerning the Use of Urea and Glycine as Protein Substitutes in Feeding Dairy Cows.)** K. Richter and W. Birzer. Ztschr. of Tierernährung und Futtermittelkunde, *4:* 59–80. 1940.

Twenty-seven cows were used in this investigation. They were divided into 4 groups, and each group was observed for 70 days with pre- and post-periods of 14 days each. Mixtures containing urea or glycine as a source of protein were consumed by the cows after a period of adjustment. At first it was difficult for the cows to consume these mixtures. As they adjusted to the diets, the glycine mixture was consumed freely and in large quantities.

The first group was fed a normal ration. The other 3 were fed various mixtures containing urea or glycine to balance the nitrogen requirements.

The experiments point to glycine as a possible nitrogen source in feeding cows. Urea as a source of nitrogen could be used to the extent of 50 per cent of the nitrogen supply; with glycine this percentage was 75. Glycine increased the fat percentage in the milk when fed to the cows. Urea as a source of nitrogen for dairy cows decreased milk production. J.C.M.

**524. Fütterungsversuche mit Rapsrückstanden an Milchkühen. (Feeding Experiments with Rape Products on Cows.)** H. BÜNGER, E. FISSMER, AND F. REISING. Ztschr. f. Tierernährung und Futtermittelkunde, *4:* 183–200. 1940.

This extensive experiment dealt with the use of rape products as rape cake, etc., upon milk yields. Standard oil cake feedings of several kinds and of known influence were used for the controls.

The rape products used included a variety of forms as pressed rape, rape cakes, and cut rape. All were fed in a dry state.

Rape products generally adversely affected milk production when substituted in rations for milk cows. When production of milk was maintained the fat content was reduced.

Rape products must also be free from mustard seed to be usable for cattle feed.

Generally the report is negative in regard to rape products for milk cows. J.C.M.

**525. Untersuchungen über die Beeinflussung der Milchfettprodukton durch Mineralstoffe. (Experiments Concerning the Influences of Minerals upon Milk Fat Production.)** J. KRIZENECKY, Tierernährung, *12:* 368–394. 1940.

Calcium, magnesium and phosphorus are associated with milk fat production according to recorded evidence cited by the author.

The author tried commercial products high in minerals with the result that mineral metabolism activated the efficiency of food stuff conversion in the body with ultimately more favorable milk production.

The author enthusiastically proclaims the theories associated with the relationship cited; and states that more factual matter should be obtained to establish reasons for the observations made. J.C.M.

**526. The Conservation of Alfalfa, Timothy and Soybean Nutrients as Silages and Hays.** A. J. NEWLANDER, H. B. ELLENBERGER, O. M. CAMBURN, AND C. H. JONES, Univ. of Vermont, Burlington, Vt. Vt. Agr. Expt. Sta. Bul. 459. 42 pages.

Alfalfa and timothy were made into hay by both sun curing and artificial drying. All three crops were made into silage by the addition of molasses and untreated lots of each were wilted and unwilted. Timothy silages were also made from both wilted and unwilted material treated with phosphoric

acid and by the A.I.V. process. Lots of soybean were likewise treated with phosphoric acid.

*Alfalfa.* The best silage, pH 4.76, was made from molasses treated material having 40 per cent dry matter and the poorest, pH 5.12, was from untreated material with 25 per cent dry matter which was putrefactive. Calculated recovery of T.D.N. from 100 pounds dry matter ensiled or made into hay was: 48.7 pounds for that wilted and preserved with molasses; 42.2 pounds for that unwilted and not treated; 45.3 for sun cured hay and 51.4 for artificially dried hay.

*Timothy.* Silages from the lots preserved with molasses and one untreated lot containing 37 per cent dry matter were equally good. The acid treated lots were well preserved but were unpalatable unless ground limestone was added when fed. The poorest lot was untreated and contained 49 per cent dry matter. The highest recovery of T.D.N. per 100 pounds dry matter ensiled was 50.9 pounds for the wilted phosphoric acid treated lot, followed by 50.2 pounds wilted molasses treated and 48.0 pounds for the A.I.V. The lowest was 47.7 pounds for the unwilted untreated. For the sun cured hay the T.D.N. recovery was 53.1 pounds and 53.1 pounds for the artificially dried hay.

*Soybeans.* Poor silage resulted with or without molasses when the dry matter content was about 25 per cent but when wilted to 31 to 33 per cent dry matter excellent silage resulted. Phosphoric acid preserved the silage well even when the dry matter was 21 to 23 per cent. The recovery of T.D.N. per 100 pounds dry matter of ensiled soybeans averaged 59.5 pounds. There were less losses of nutrients in the molasses treated than in the acid treated silages except for crude protein. W.E.P.

## FOOD VALUE OF DAIRY PRODUCTS

527. **Therapeutisch verwendete Sauermilch inbesondere Joghurt und Buttermilch. (Therapeutic Value of Sourmilk with Special Reference to Yogurt and Buttermilk.)** S. HOFFMAN. Schweiz Milch. Ztg. *43:* 28 and continued in *44:* 215 and in *45:* 219. 1940.

This article covers completely the types of organisms normally found in yogurt and buttermilk. The ideas of implantation are discussed; but the theme of the report centers in the value of these drinks because of their protein structure. It is shown that the protein in these milks is readily digestible making them very desirable for children. J.C.M.

528. **Cows' Milk Treated by Base Exchange for Infant Feeding. Metabolism of Calcium, Phosphorus and Nitrogen.** JULIUS H. HESS, HENRY G. PONCHER, HELEN W. WADE, AND JEANETTE C. RICEWASSER. Amer. Jour. Dis. Children, *60:* 535–547. 1940.

Unboiled base exchange-treated milk, when fed in the proportion of 1¼

ounces per pound of body weight, kept 6 infants below the age of 1 year in positive calcium, phosphorus and nitrogen balance. Essentially the same amounts of calcium, phosphorus, and nitrogen were absorbed and retained from boiled whole milk as from unboiled base exchange-treated milk. The authors conclude that the reduction of calcium and phosphorus content of milk by the process of base exchange does not impair the nutritive value of this milk. W.H.R.

**529. The Need of Milk in the South.** O. D. ABBOTT, Agr. Exp. Sta., Gainesville, Fla. Jour. Milk Tech., *3:* 354–356. 1940.

According to the 1930 U. S. census, the South has 35 per cent of the children under 15 years of age and only 17 per cent of the milk.

In Florida the milk production for the state was sufficient to provide less than 0.4 pint of milk per person per day.

Health records for the State on 10,000 school children show abnormal height-age relationship, vitamin A deficiency and carious teeth. These symtoms indicate a lack of milk in the diet. L.H.B.

**530. Determining Riboflavin in Dried Milk Products. II. Season Variations.** ROYAL A. SULLIVAN AND EVELYN BLOOM, Kraft Cheese Co., Chicago, Ill. Jour. Milk Tech., *3:* 346–349. 1940.

Dried whey (whey obtained after cheesemaking operation) from six drying plants located in five states and having a total annual production of 5,300 tons of dried whey was used as a basis for determining the seasonal variations over a period of two years. Bimonthly samples were tested by a photometric procedure for riboflavin concentration. The method is based upon the extraction of riboflavin with acid-acetone and the distinction of colored impurities by mild oxidation. After filtration, the riboflavin concentration is measured by the determination of light absorption before and after reduction to the leuco form.

The average value of 244 samples was 25.1 micrograms of riboflavin per gram. The mean average for the various seasons was as follows:

| | | | |
|---|---|---|---|
| Summer | $25.6 \pm 0.27$ | Winter | $23.8 \pm 0.39$ |
| Autumn | $25.6 \pm 0.32$ | Spring | $25.0 \pm 0.29$ |

There was very little difference for any of the seasons. The winter had the lowest value but even this was only seven per cent lower than that for summer. L.H.B.

**531. The Passage of Carotenoids from Food to Milk in the Cow. The Fate of Lycopene.** A. E. GILLAM, Dept. Chem., Univ. of Manchester, and S. K. KON, Nat. Inst. for Res. in Dairying, Univ. of Reading, England. Jour. Dairy Res., *11:* 266–273. 1940.

Evidence was secured that the tomato pigment, lycopene, an isomer of carotene, cannot pass from food into milk in the cow. Three different cows

were fed tomato juice and the resulting milk fats examined separately for lycopene. No indication of the presence of lycopene was detected in the unsaponifiable matter of butterfat when this was subjected to chromatographic adsorption. Lycopene was found in the feces in considerable quantity after tomato feeding. S.T.C.

## ICE CREAM

**532. Dextrose and Corn Syrup for Frozen Desserts.** A. C. DAHLBERG AND E. S. PENCZEK. Ice Cream Field, *37*, No. 3: 36. 1941.

The authors report results obtained with three different types of corn sweeteners used to replace part of the sucrose in ice cream, ices and sherbets. These sweeteners are: (1) an enzyme—converted corn syrup—a new type of liquid corn syrup; (2) corn syrup solids—a dried regular corn syrup; and (3) a hydrated dextrose or corn sugar. They give the relative sweetness of the products studied (on a dry basis) as follows: sucrose 100, enzyme-converted corn syrup 67, corn syrup solids 49, and dextrose 89.

Ice cream mixes were made according to accepted commercial procedures and were prepared to contain 12 per cent milk fat, 10 per cent milk-solids-not-fat, 15 per cent sucrose or its sweetness equivalent, 0.4 per cent gelatin and 0.3 per cent dried egg yolk. The experimental samples were frozen in 1 gallon hand freezers which rotated in cold brine.

Best results were obtained when 25 per cent of the sucrose was replaced with dextrose or corn syrup to give comparable sweetness. Concentrations much greater than this affected adversely the hardness of the ice cream as well as its melting rate.

Titratable acidity of the mixes was not affected by the corn sweeteners but the pH was slightly lowered in the case of the corn syrups. There was no marked effect upon the viscosity or surface tension of fresh mixes as a result of using corn sweeteners, but aged mixes showed a greater viscosity where such sweeteners were used.

The enzyme-converted corn syrup was slightly superior in fresh ice cream and this syrup possessed anti-oxidation properties. They report that both corn syrup and dextrose samples developed an oxidized flavor in 8 weeks of storage, also that in certain cases the color of these samples became bleached.

The development of sandiness was not materially affected by corn sweeteners. Results secured with vanilla and maple-nut ice creams used in these experiments were not constant.

Consumers were unable to identify ice creams on the basis of the presence or absence of corn sweeteners but experts could be trained to do so.

In the case of ices and sherbets sucrose crystallization was prevented by a replacement of 25 per cent of the sucrose with corn sweeteners. W.C.C.

**533. Bugaboo of Barriers.** PAUL T. TRUITT. Ice Cream Field, *37:* No. 3: 2. 1941.

The author claims that a trade barrier is "a statute, regulation, or practice which operates or tends to operate to the disadvantage of persons, products, or services coming from sister states to the advantage of local residents." He classifies trade barriers as follows: 1. Those laws which on their face discriminate against out-of-state-enterprise. 2. Those laws which on their face are non-discriminatory but which in practice discriminate against out-of-state enterprise. 3. Laws which apply to residents and non-residents alike which, if encountered in several states, impose a cumulative burden which is a trade barrier. 4. Laws which become trade barriers by virtue of unfair discriminatory administration.

Tabulations now under way will likely show over 3,000 state laws which create or tend to create barriers to the free flow of commerce between states. Forty-one states have enacted laws giving local residents some kind of preferences over non-residents; thirty states limit this preference to state products whereas twenty-four give preference to the home state on printing.

Duplicate inspection requirements for various dairy products have erected barriers between states and in some instances between counties and cities. Examples of such barriers are cited.

There is a reaction on the part of the public against such trade barriers, certain of these laws have been repealed, and other proposed barriers have been defeated. It is suggested that rather than have the Federal Government or the respective State Governments attempt to regulate this problem alone, it would be best to have joint action by the State Governments and the Federal Government, each supporting and reenforcing the others.

The objectives of any program to eliminate trade barriers should be: (1) to prevent the enactment of new trade barrier laws and (2) to obtain the repeal or modification of existing trade barrier laws. W.C.C.

**534. Trade Barriers.** WILLIAM H. LIST, JR. The Pa. and N. J. Assoc. Ice Cream Mfrs. Ice Cream Field, *37,* No. 3: 22. 1941.

The author calls attention to Pennsylvania's Act No. 210 dealing with regulation of dairy products. He points out that this law discriminates against dairy products produced in other localities because it does not recognize dairy inspection except under the direction of the Pennsylvania Secretary of Health.

He is in accord with the suggestion of H. A. Ruehe to the effect that "reciprocal acceptance of equivalent quality standard of inspection by health authorities of states, counties and municipalities, would result in a free flow of dairy products from state to state, city to city."

He states that the International Association of Ice Cream Manufacturers

as well as leaders of the industry are in accord with such a plan, but claims that it will be necessary to enlist public opinion in its support in order to accomplish the desired results. W.C.C.

**535. Ice Cream Sales Index for 1940. Statistical and Accounting Bureau.** Internatl. Assoc. Ice Cream Mfrs., Washington, D. C. Special Bul. 65. May, 1941.

The increase in sales of wholesale ice cream for 1940 was found to be 2.56 per cent higher than for 1939. This means that in 1940 the largest total gallonage of wholesale ice cream on record was sold. It is estimated that the wholesale gallonage for 1940 was 284,470,672, while the total gallonage was 310,971,115. In Canada the 1940 sales of ice cream were 15.06 per cent higher than in 1939.

A supplement to the bulletin contains statistical data of value, such as: ice cream production departure from 10-year average; average temperature by months; ice cream production for 1939, by months; wholesale ice cream production, 1921 to 1940, inclusive; and the per capita production of ice cream by states, for 1939. M.J.M.

**536. The Use of Whipped Cream in Fancy Forms.** B. I. Masurovsky, Research Editor. Ice Cream Trade Jour., *37:* 36. May, 1941.

With an increase in usage of whipped cream for the decoration of ice cream products it is desirable to know a few facts pertinent to achieving the highest type of product. Rather than use a slightly sweetened 40 per cent butterfat or "heavy" cream, a 30 per cent butterfat cream with 6 to 7 per cent sugar and extra serum solids such as are supplied by condensed skim-milk was used. This was whipped at a temperature of 40° F. and resulted in a product with a better whip and a firmer body. The added sugar is desirable in that it lessens the difference in flavor between the base product and the icing.

Some points for decorating ice cream are: increase the sugar content of whipped cream; have the surface of the base hardened prior to decorating; have smooth edged stencils; use care and rapidity in applying stenciled designs; and be equipped with suitable, convenient facilities for rapid cooling of moulds, cakes, etc.

In decorating ice cream pies, follow the trend usually practised by the pastry chef in designs. Use little or no coloring.

Ice cream cakes should be trimmed with natural or egg color shade cream. Flowers and leaf designs are best made with two tones of some color, *i.e.*, leaves of light green, stalks and the main parts of the plant of a darker green.

The following rules should be given to the consumer as a guide to proper handling of such ice cream desserts:

1. Examine 20 minutes before serving.
2. If too hard, remove the dry ice.
3. Do not touch the dry ice with the bare hands.
4. Wet knife blade with warm water so the blade will cut clean.

W.H.M.

**537. What Is the M.Q. of Your Ice Cream Sales Staff?** H. H. CURNUTT, Steffan Ice and Ice Cream Co., Wichita, Kansas. Ice Cream Trade Jour., *37:* 22. April, 1941.

A "M.Q." merchandising quotient test for the ice cream sales staff is presented and analyzed. Ten items are covered in the Quiz. The first 5, each allotted 15 points, deal with the salesman's attitude toward the dealer and the last five, each allotted 5 points, related to the dealer's attitude towards the merchandiser. A score of 100 entitles the salesman to the master merchandiser rating.

To get a perfect score the salesman should answer yes to the following 15 point questions:

1. Do you spend 50 per cent of your time with fountain personnel when calling on dealer?

2. Have you increased sales at 10 per cent of your accounts whose sales were down in the last 6 months?

3. When calling on a dealer do you approximately divide your time in the following proportions? 10 per cent visitation; 30 per cent advertising; 30 per cent sales; and 30 per cent operations.

4. Can you give an accurate report on the consumer trends around each of your dealers?

5. Is it a false statement that, "Some Dealers Cannot Be Merchandised?"

W.H.M.

**538. A 5,000,000-Gallon Delivery System.** JOHN W. BURDAN, Philadelphia Dairy Products Co. Ice Cream Trade Jour., *37:* 14. April, 1941.

The Philadelphia Dairy Products Company which distributes 5,000,000 gallons of ice cream annually in six states and which operates 170 trucks and cars, has a series of records and reports which has enabled it to determine the cost of delivering ice cream. Taking all costs into consideration, including drivers' wages, it costs 1.7 cents a quart or 6.8 cents a gallon. Truck depreciation amounts to one cent a mile and truck repairs average 7 to 8 mills. The company estimates the average life of their trucks at 100,000 miles.

The control system gives a complete record of the performance of each truck. It shows charges for drivers' wages, repairs, oil, gas, refrigeration,

maintenance, insurance, tires and tubes, garage rent, tool charges, and accessories such as skid-chains and anti-freeze solution. Savings in oil consumption have been made by installing oil filters on each unit and changing oil only when necessary rather than at a specified mileage. They have found it economical to supply their own mechanics at certain points. Additional savings have been affected by installing a safety program as careless driving may greatly increase the cost of truck operations. W.H.M.

**539. Ice Milk.** PAUL VASTERLING, Dufold Company, Racine, Wis. Ice Cream Trade Jour., *37:* 26. April, 1941.

The author suggests the following formula for Ice Milk: 4 per cent fat, 17 per cent solids-not-fat, 16 per cent sugar, and 0.4 per cent stabilizer, and recommends that the mixture be pasteurized at 160° F. for 30 minutes, homogenized at 2500 pounds pressure, and frozen in a continuous freezer to about the same overrun as ice cream. The material, costing about 17 cents a gallon, will produce a product which usually wholesales for 64 cents a gallon in pint containers. The retailer then sells them for 10 cents each. Most manufacturers limit the 10 cent pint to four flavors.

There is no need to misrepresent the product. It should be labeled "Ice Milk" and the author suggests that the states adopt the proper regulating measures to permit its sale. W.H.M.

**540. The Ratio of Total Solids to Butterfat.** B. I. MASUROVSKY, Research Editor. Ice Cream Trade Jour., *37:* 61. April, 1941.

An optimum ratio of butterfat to total solids-not-fat of 1 : 2.4 in ice cream is suggested. Such a ratio offers protection against crystallization of milk sugar in the frozen ice cream and makes it possible to obtain 100 per cent overrun and still comply with a requirement of 1.6 pounds of food solid per gallon of ice cream. Ice cream weight charts are presented which show the ratio of butterfat to total solids-not-fat in mixes with varying percentages of total solids.

A fixed standard ratio of 1 : 2.4 will not apply to every type of ice cream; however, it can be varied to meet local conditions. W.H.M.

**541. Merchandising Innovations.** ANONYMOUS. Ice Cream Trade Jour., *37:* 29. April, 1941.

Unorthodox, yet result producing, is the sale of ice cream by weight to the customers in their own containers practised by the Queen City Dairy of Cumberland, Md. A 13 per cent fat product that weighs 4½ pounds per gallon is sold for 20 cents a pound, hand-dipped. The salesgirls are schooled in explaining that such is practised to assure the same amount of ice cream to every customer.

Other innovations of the Queen City plant is the putting on a "show" for the customers' benefit when serving any product, whether it be a sundae or a malted milk. "Make the customer see his money's worth" is the philosophy practised by the sales girls. Malts are made by pouring a full half-pint of milk into the cup, adding 2 "slices" of ice cream and a dash of whipped cream—all of which looks large. Dishes are served with 2 "slices" of ice cream rather than one with the idea of creating the effect of quantity as well as quality.

Important, too, is the use of a high-type sales girl who knows how to learn her job and will readily fit into the mould of sales procedures of the store already established. W.H.M.

**542. Milk and Ice Cream Drinks.** LOUIS D. JONES. Ice Cream Trade Jour., *37:* 30. May, 1941.

Since the mixed milk and ice cream drink represents the major channel of outlet of ice cream at the soda fountain, the wholesaler of ice cream as well as the retailer should know what the public desires. A government survey shows that 26.88 cents of the retail ice cream dollar was spent for mixed milk and ice cream drink; 24.55 cents for carry-outs; 22.78 cents for sundaes; 19.08 cents for sodas; and 6.71 cents for novelties. The finding of a national research bureau was that more than 50 million dollars was spent for milk and ice cream drinks than was spent for all other soft drink beverages as soda, carbonated fruit juices, and colas sold over the soda fountain.

The prerequisite of a good milk and ice cream mixed drink is taste; and the taste is dependent upon the quality of ingredients, which must be high, and the smoothness of mixing of the ingredients. Purpose of mixing is to blend the flavor constituents and to aerate or fluff the drink for the desirable smoothness. Proper mixing is dependent upon the products used and the type of finished product desired. A well designed mixer will not beat the overrun out of the ice cream at the same time incorporating overrun into the milk and blending the flavors together.

Milk at 32° F. will whip to a 90 per cent overrun, while at 40° F. the overrun is only 82 per cent or a decrease of 13 per cent, with another 8° F. increase to 48° F. the overrun is 55 per cent. Thus it can be seen the importance of maintaining proper temperatures of ingredients of the mixed drink. W.H.M.

**543. Payload Progress.** VINCENT M. RABUFFO. Ice Cream Trade Jour., *37:* 10. April, 1941.

The delivery costs of ice cream have been reduced by increasing the size of the pay load and by reducing the size of the truck chassis. Dry ice and

mechanically refrigerated truck bodies have lowered refrigeration costs and prolonged the life of delivery equipment over what it was when ice and salt were used. By reducing the size of the truck there has been a further saving in the cost of a truck license. Today a one and one-half ton truck can haul 1,000 gallons of ice cream at a per day cost of less than $5.00 or a mileage cost of less than $0.07 which is one-fourth to one-third the cost which prevailed a few years ago. W.H.M.

## MILK

**544. Der Einflusz des Gefrierens auf entrahmte Milch. (The Influence of Freezing upon Creamed Milk.)** H. OSTERMANN AND E. PREVOT. Deut. Molkerei Ztg., *25:* 51–52. 1940.

The freezing point, specific gravity, degree of acidity, and composition of creamed milk frozen solid were observed. The main findings pointed out the necessity of completely thawing and mixing such milk before use. Although partial thawing appeared to produce uniform portions of upper and lower milk, actual analysis showed wide variation in composition due to a lack of completely thawing before using. J.C.M.

**545. Ascorbic Acid Content of Cow's Milk at Various Stages at Lactation.** ARTHUR D. HOLMES, FRANCIS TRIPP, E. A. WOELFFER, AND G. H. SATTERFIELD. Amer. Jour. Dis. Children, *60:* 1025–1030. 1940.

Three hundred fifteen samples of Guernsey milk, and three hundred thirty-seven samples of Holstein milk were assayed for ascorbic acid content. Of these samples, 75 to 90 per cent for each breed, respectively, were of milk produced during the second to eleventh months of lactation.

The ascorbic acid content of both Guernsey and Holstein milk rose rapidly during the first two months of lactation. From the second to the eleventh months, a slight decrease was observed. Average monthly values for ascorbic acid in Guernsey milk varied from 19.39 mg/1000 cc. for the eighth month to 21.49 mg. for the second month. For Holstein milk, the range in variation was from 15.68 mg. for the first month to 18.85 mg. for the fifth month. W.H.R.

**546. How Equipment Selection Influences Plant Design and Operation.** H. MCNABB, Sheffield Farms Co., New York, N. Y. The Assoc. Bul., Internatl. Assoc. Milk Dealers, 33rd Year, *15:* 393–398. March, 1941.

The arrangement of plants to allow milk to flow by gravity from one piece of equipment to another, each on a different floor level, has resulted in many extra steps in getting from one piece of equipment to another and has

made it difficult to remodel or adapt the plant for other uses. Support columns and the resulting loft type building efficiently accommodates various operations with low cost and flexibility. In another plant, by leaving out parts of the second floor, the equipment appeared to be on balconies and an effect of spaciousness was obtained. The remainder of the second floor can be filled in as needed. Floors need to carry heavier loads than formerly and attention is called to the fact that certain 5500 gallon tanks do not have the load evenly distributed among the legs. An instance is given of a 5 leg buttermilk tank, where the center leg carried half the load or 6,250 lbs., the remaining weight being divided between the other 4 legs.

Locating floor drains near columns has left the center of the floor thicker and stronger and obviates having drains under equipment. At each corner of every column a 6-inch floor sleeve is installed to obviate cutting the floor for pipes later. Also all vertical pipes have plugged tees just below the floor slab for future connections.

Additional electrical switches are installed for future use and heavy duty elevators to move machinery. Triple doors and some masonry wall sections not bonded into the remainder of the wall make moving large machines easier. E.F.G.

**547. A Proposed New Common Sense Milk Can.** H. A. TREBLER, Sealtest, Inc., Baltimore, Maryland. The Assoc. Bul., Internatl. Assoc. Milk Dealers, 33rd Year, *15:* 393–398. March, 1941.

This can is seamless, 16 gauge metal with an 8½″ diameter straight neck and no pouring lip. An Umbrella type cover is used. The breast of the can tapers down far enough so that all of the inside can surface may be seen. The handle is the upright stiff metal type, placed a little lower down than usual. The bottom has large drain holes, permitting alkali solution and water to drain off rapidly.

The advantages of the can are that it will drain about 30 per cent faster and leaves 2 ounces less milk in each can when draining 14 cans per minute. It is cleaned easier with a hydraulic washer and the cost of manufacture of the can should be somewhat less. E.F.G.

**548. Bacteriological Aspects of Farm Milk Cooling.** T. G. ANDERSON. Pa. Agr. Expt. Sta. Bul. 404. 1941.

In this study of farm milk cooling, the use of well water was compared in effectiveness with electrical refrigeration. The results obtained by taking samples of milk at three levels in a 10-gallon can showed positive necessity for quick and complete cooling. The difference in numbers of bacteria before and after cooling for 12 hours emphasized the importance of low temperatures. The rise in temperature of cooled milk during transportation indicated the need of proper protection during hauling to receiving plants. Author's Abstract

**549. Testing the Sterility of Bottles.** H. BARKWORTH, Dairy Indus., *6:* 35. 1941.

The technique proposed by Mattick and Hoy (a 20 cc. rinse) was found to be superior to the conventional 90 cc. rinse. The proposed standard of 200 bacteria per bottle can be maintained commercially. When this standard is enforced a coliform test gives no additional information and is superfluous. D.V.J.

**550. Can Cleaning and Sterilization.** A. L. PROVAN AND A. R. TREBLE. Dairy Indus., *6:* 5. 1941.

With the support of experimental bacteriological data the authors demonstrate the importance of returning clean dry milk cans to the farm. Mechanical and hand can washing are discussed and control measures to insure efficient sterilization are suggested. D.V.J.

**551. Practical Plant Operating Problems.** HANS EDEL, Gehl's Guernsey Farms, Milwaukee, Wis. The Assoc. Bul., Internatl. Assoc. Milk Dealers, 33rd year, *15:* 404–408. Mar., 1941.

Refrigeration efficiency is obtained in a number of ways, among which are low discharge pressure by means of frequent purging and draining oil from the system. Frequent defrosting promotes efficiency. A booster pump on the suction line may help. Frosted cylinder walls are an indication of inefficient operation.

It is recommended that scale be removed from a bottle washer by means of 8-hour treatment with a 6 per cent hydrochloric acid solution plus perhaps 3 to 6 ounces of inhibitor per carboy of acid to prevent corrosion.

Figures are given to show 4.85 pounds of washing powder per 1000 bottles were used before descaling and 1.2 pounds of washing powder were used per 1000 bottles after descaling the washer. E.F.G.

**552. Dairy Herd Management Practices Affecting the Quality of Milk.** A. C. RAGSDALE, Dairy Husbandry Dept., Univ. of Missouri. Jour. Milk Tech., *3:* 350–353. 1940.

Practices affecting the quality of milk are discussed together with control methods which may usually be found effective. L.H.B.

**553. Application of the Resazurin Test in Determining the Quality of Pasteurized Cream.** W. H. CHILSON AND M. A. COLLINS, United Farmers Cooperative Creamery Assoc., Inc., Boston, Mass. Jour. Milk Tech., *3:* 334–340. 1940.

Using 1.0 ml. of 0.005 per cent resazurin solution to 10.0 ml. of cream and incubating at 98° F. until a pronounced pink color was obtained would

give reliable information within a few hours after pasteurization of the quality of the cream. A reduction time of six hours or longer (to pronounced pink color) indicated fine quality in pasteurized 20 or 40 per cent cream. Such cream will generally show not more than 40,000 bacteria per ml. when aged four days at 40–45° F.

A reduction time of over five hours usually indicates a standard plate count of less than 100,000 bacteria per ml. in nine of ten samples and of 40,000 or less in seven of ten samples.

When the test is applied to pasteurized cream, which has been stored at temperatures of 40° F. or lower for four or more days, it could not always be depended upon to indicate high counts.

There was a much closer agreement between the resazurin test and the standard plate count than between the rise in acidity upon incubation at 72° F. for 15 hours and the standard agar plate count. L.H.B.

**554. A Modified Resazurin Test for the More Accurate Estimation of Milk Quality.** C. K. Johns and R. K. Howson, Dominion Dept. of Agr., Ottawa, Canada. Jour. Milk Tech., *3:* 320–325. 1940.

A study was made of 279 samples of market milk to determine a simple method of routine grading which would combine the sensitivity of the "one-hour" test for abnormal milk with the greater accuracy of the resazurin "pink" end point for bacteria. This was found to be color number 8, described as P 7/4 according to the Munsell system of color notation.

By the use of this standard, milk may be classified into four grades in three hours time. All samples showing a color number in excess of 8 at 1 hour would go into the 4th grade. Those showing such a change at 2 hours would go in class 3; those showing the change at 3 hours would go in class 2; and those not showing such a change in 3 hours would go in class 1.

The use of a daylight lamp is important in making color comparisons. A 15-watt (General Electric) Mazda fluorescent daylight lamp with a neutral grey background was found superior to other types of daylight lamps tried. L.H.B.

## PHYSIOLOGY

**555. Influence of Thyroidectomy on Fat Deposition in the Rat.** Eaton M. Mackay and James W. Sherrill. Endocrinology, *28:* 518. 1941.

Thyroidectomy in the adult male albino rat resulted in a marked reduction in the amount of body fat in comparison with unoperated controls of the same age when they were killed 10 months later. The thyroidectomized rats, in spite of their low fat content, neither appeared less plump nor did they weigh appreciably less than the controls. The inclusion of active thyroid substance in the diet produced the usual decrease in body fat.

R.P.R.

**556. Qualitative Progesterone Assay of Pregnant Cattle AP and Extracts Having Mammary Growth Activity.** J. J. TRENTIN, J. P. MIXNER, A. A. LEWIS, AND C. W. TURNER. Soc. Exptl. Biol. and Med. Proc., *46:* 440. 1941.

Fresh pregnant cattle pituitary tissue in amounts which stimulated growth of the lobule-alveolar system in spayed mice was found to contain insufficient progesterone to produce a positive response by the sensitive McGinty technic. Lipid extracts of the AP which stimulated duct growth in the male mouse were also found to be negative for progesterone. The authors believe that these observations indicate that neither the mammogenic duct nor lobule-alveolar effects of the AP are due to the presence of progesterone. R.P.R.

**557. The Assay of Prolactin by Means of the Pigeon Crop-Gland Response.** S. J. FOLLEY, F. J. DYER, AND K. H. COWARD. Jour. Endocrinology *2:* 179. 1940.

The results of lactogen assays by the pigeon crop-weight method were analyzed statistically. For a given dose of hormone there was a positive correlation between crop-weight and body-weight. A sigmoid curve was obtained when either absolute crop-weight or crop-weight expressed as a percentage of body-weight was plotted against hormone dose. The relationship between either of these quantities and log dose was approximately rectilinear for total doses from 3 to 18 I.U. The limits of accuracy of the assay method compared favorably with other biological assays. Temperatures above 15° C. decreased the stimulation of the crop-glands by lactogen while light had no influence upon the response. A subjective estimate of the crop-milk of pigeons injected with lactogen was suggested as the basis of an approximate assay method. It was suggested that the following conditions should be observed in order to attain a satisfactory degree of accuracy in lactogen assays: 1. Each group should consist of 15–20 birds; 2. All birds should be kept at the same temperature, preferably near 15° C.; 3. The body-weights of the birds should lie within the limits of 260 to 360 grams; 4. Hormone injections should be made subcutaneously; 5. Simultaneous comparison between the unknown and the standard preparation of lactogen should be made; and 6. Calculations should be made on the basis of crop-weights expressed as percentages of body-weights. R.P.R.

**558. Prolactin as a Specific Lactogenic Hormone.** S. J. FOLLEY AND F. G. YOUNG. Lancet, *240:* 380–381. 1941.

A review of the literature with 32 references. J.F.C.

**559. Effects of Oestrogens on Lactation.** S. J. FOLLEY, Nat. Inst. for Res. in Dairying, Univ. of Reading. Lancet, *240:* 40–41. 1941.

A review of the literature with 33 references. J.F.C.

**560. Further Experiments on the Continued Treatment of Lactating Cows with Anterior Pituitary Extracts.** S. J. FOLLEY AND F. G. YOUNG. Jour. Endocrinology, *2:* 226. 1940.

The injection of a crude anterior pituitary extract subcutaneously on 11 alternate days into cows in declining lactation increased the average daily milk production during the injection period to 16 per cent above that expected in the absence of treatment. Similar injections of a lactogen preparation increased the average milk yield to only 5 per cent above that expected. In both instances milk production declined in magnitude towards the end of the injection period, but no evidence was found for the presence of antilactogen activity in the serum of the cows at that time. The injection of a pituitary preparation having glycotropic activity but no detectable lactogen had no obvious influence on the milk production of cows in declining lactation. The content of fat or of non-fatty solids in the milk was not affected by the pituitary injections. R.P.R.

## MISCELLANEOUS

**561. A Study of the Sensitiveness of Prospective Food Judges to the Primary Tastes.** DARLINE KNOWLES AND P. E. JOHNSON, North Dakota Agr. Exp. Sta., Fargo, N. D. Food Res., *6*, No. 1: 207. Mar.–Apr., 1941.

In a study using 19 men and 18 women it was found that individuals varied widely in their ability to detect low concentrations of substances producing the four primary tastes. There was no significant difference between the ability of the men and that of the women. Of the 37 people participating five were rated excellent, four good and three fair. No correlation was noticed between judging ability and age, experience in judging or smoking. The authors state that results show the necessity for testing the tasting ability of individuals previous to making selections for a panel of judges in the examination of foods. F.J.D.

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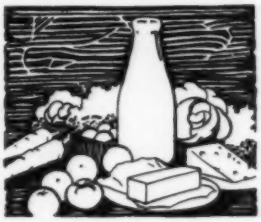

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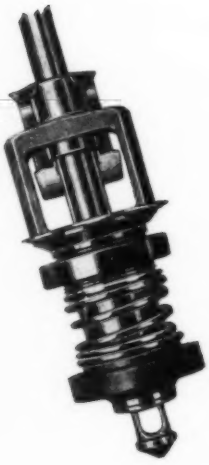

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## *Isolation of Strains*

Bacto-Tryptose Agar is recommended for isolation of *Brucella* from all types of infected milk. The medium used for this purpose should be prepared with Bacto-Crystal Violet (DC-2) to inhibit development of the Gram-positive streptococci. For isolation from blood specimens preliminary enrichment of the sample in a broth prepared with Bacto-Tryptose is recommended before inoculation on plates of tryptose agar.

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## *Differentiation of Types*

Bacto-Tryptose Agar to which thionin or basic fuchsin have been added is recommended for differentiation of newly isolated strains of *Brucella.*

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## *Mass Cultivation*

Bacto-Tryptose Agar, prepared without addition of dyes or other ingredients, supports luxuriant growth of all *Brucella.* It is an excellent medium for mass cultivation of the organisms for preparation of bacterial vaccines or antigens.

*Specify "DIFCO"*

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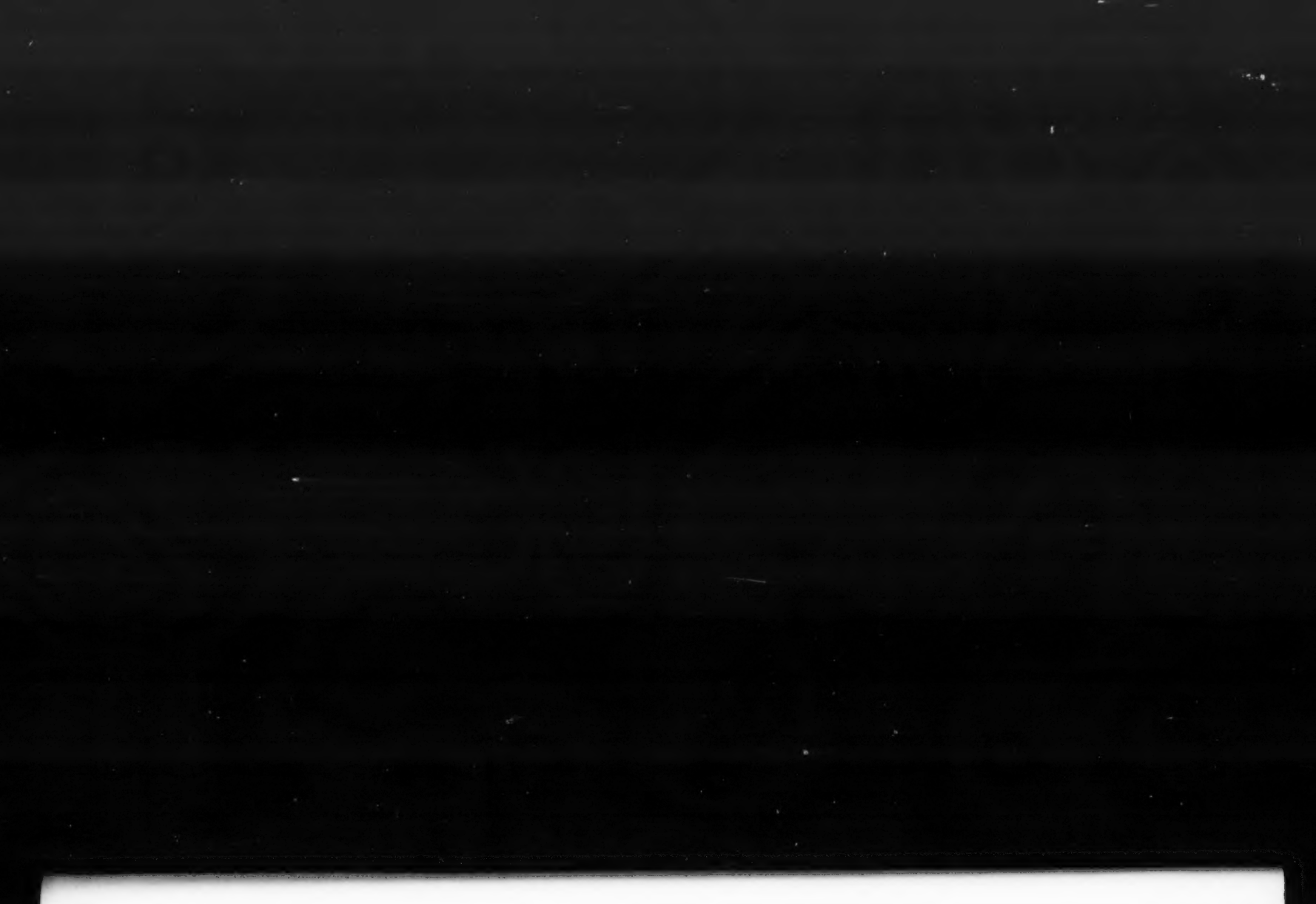
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